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Report of the

# TECHNICAL CONSULTATION ON STOCK ASSESSMENT IN THE ADRIATIC

## General Fisheries Council for the Mediterranean (GFCM)

Split, Yugoslavia, 2-6 June 1980

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

# REPORT OF THE
# TECHNICAL CONSULTATION ON STOCK ASSESSMENT
# IN THE ADRIATIC

Split, Yugoslavia, 2-6 June 1980

GENERAL FISHERIES COUNCIL FOR THE MEDITERRANEAN

WORKING PARTY ON RESOURCE APPRAISAL
AND FISHERY STATISTICS

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome 1980

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ABSTRACT

The final formal report of the Technical Consultation on Stock Assessment in the Adriatic held in Split, Yugoslavia, from 2 to 6 June 1980, is presented. Major topics considered were: (1) description of main Adriatic fisheries; (2) possibilities of regional collaboration in the field of fishery statistics; (3) collaboration in the legal sector; and (4) establishment of a coordinated fishery research programme in the Adriatic. Among the recommendations of the meeting were: (1) increased contact between the scientists of the region; (2) establishment of a sampling network; (3) coordination of direct appraisal methods; (4) execution of experiments in electronic calibration; (5) studies on mortalities and fluctuations; (6) compilation of a biological data base; and (7) harmonization of legal regulations. Eight annexes include the text of papers presented to the meeting.

Distribution

Participants
Member countries of the General Fisheries Council for the Mediterranean
Other countries and national and international organizations interested
FAO Fisheries Department
Regional FAO Fishery Officers

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INTRODUCTION

1. The Technical Consultation on Stock Assessment in the Adriatic was held from 2 to 6 June 1980 at the Oceanography and Fishery Institute of Split at the kind invitation of the Government of Yugoslavia, and by virtue of the recommendations of the Seventh Session of the Working Party on Resources Appraisal and Fishery Statistics (Rome, 1978) and the conclusions of the Fourteenth Session of the GFCM (Nantes, 1978).

2. Dr S. Alfirević, Vice-Chairman of the GFCM, coordinator of the meeting, opened the Consultation by welcoming the participants, who are listed in Annex B. Mr S. Garcia, Technical Secretary of the Working Party, speaking on behalf of the Director of the FAO Fisheries Department, thanked the Yugoslavian authorities for their efforts in the organization of this meeting, and the participants for their collaboration, and expressed the wishes formulated by the Director of the Department for its full success. Mr S. Surjak, Chairman of the Committee for Education, Training, Science, Culture and Physical Education of the Community of Communes of Split, greeted the participants. Mr R. Stijelja, Director of the Oceanography and Fishery Institute, wished the participants a fruitful consultation. Mr G. Bombace, Director of the Institute of Fishery Technology of Ancona, expressed thanks for the welcome given to the participants.

3. Messrs S. Jukić and D. Levi were elected Chairman and Vice-Chairman of the Consultation, respectively.

4. The agenda appearing in Annex A was adopted.

## I. IMPORTANCE OF SCIENTIFIC ASSESSMENT OF STOCKS

5. In a brief introductory statement to the work of the Consultation it was emphasized that, although the Mediterranean Sea has been studied traditionally by very famous scientists from laboratories, some of which go back to the origins of marine science, its demersal and pelagic resources, their potential and optimal exploitation conditions are still very little known.

6. This state of affairs is due on one hand to the complexity of the Mediterranean, and on the other hand to the fact that the studies have been only very recently and partially directed to rational resource management, and lastly to the fact that beyond traditional exchanges of scientific data, effective regional or international collaboration in the fishery research sector may not have been sufficiently intensive.

7. In this respect the Adriatic occupies a privileged position, as its long scientific tradition and its research potential should be an asset for rapid development of regional collaboration.

## II. DESCRIPTION OF MAIN ADRIATIC FISHERIES

### State of demersal stocks

8. A brief joint exposition of Yugoslavian and Italian researchers (reproduced in Annex C) shows that Yugoslavia's total catch was 37 500 t in 1978, of which 30 000 t were pelagic fish. Italian catches, according to this report, would be 137 500 t for 1977, of which 80 000 were demersal fish.

9. After a brief outline of the main results obtained in the research sector, it was mentioned that a rough appraisal of demersal stock potential had been attempted by trawling (from a small sample area, to be sure), giving a maximum production of 53 000 to 107 000 t for the entire Adriatic (Jukić and Piccinetti, 1979)1/.

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1/ S. Jukić and C. Piccinetti (1979) Standing stock estimation and yield per exploitable biomass (YEB) forecast of the Adriatic edible demersal resources. Invest.Pesq., Barc., 43(1):273-82

10. Another evaluation based on utilization of catch and effort statistics from 1959/60 to 1973/74 led to an assessment of 73 000 to 83 000 t, suggesting that a total catch increase of 10 to 20 percent for that period was possible but at the cost of a 33 to 100 percent increase of effort (see report of the Sixth Session of the Working Party on Resource Appraisal and Fishery Statistics). However attention was drawn to the fact that, as it was based on statistics whose poor quality is well known (Italian catch landed is considerably underestimated, effort an extremely rough estimate) this evaluation should be considered with caution.

State of pelagic stocks

11. A Yugoslavian and an Italian report were presented successively and are reproduced in Annexes D and E, respectively. The first sums up the data on distribution of pelagic species (sardine, anchovy, sprat) and their biology. It indicates that the pelagic species biomass was assessed at 122 000 t in 1977 and 118 000 t in 1978 (in the Yugoslavian zone).

12. A study is underway at the Split Institute showing the possibility of using Fox and Schaefer models for assessment of Yugoslavian pelagic resources.

13. The Italian researchers of the Ancona Institute summarized their work. They analysed the pelagic population structure (species, size of banks, concentration structures) and identified distribution variations from one year to another (see Annex E).

14. The average densities measured by ecosounding in the sardine concentrations in the area explored ranged from 46 t/mi$^2$ to 55 t/mi$^2$ between 1975 and 1977. Sardine distribution is probably relatively stable but abundance is likely to have increased from 1976 to 1977 (180 000 t to 320 000 t).

15. With respect to anchovy, average density found in the area explored was 150 t/mi$^2$ in 1978.

16. The study on biomass assessment by surveying eggs and larvae, conducted jointly by Italian and Yugoslavian researchers, was presented (see Annex F). The main preliminary results were presented in a description of the major lines of the methodology employed. For anchovy they show a substantial increase in the biomass[1/] from 927 000 t in 1976 to about 3 200 000 t in 1979. For sardines, the biomass probably rose from 402 000 t in 1978-79 to 963 000 t in 1979-80.

17. In the long discussion that followed many questions were raised concerning the techniques employed, the possibilities of bias, appraisal of basic fertility, the number of eggs laid by individuals per year, etc.

18. It was noted that there was no contradiction, in a first approximation, between the order of magnitude of these biomasses and those calculated by eco-survey, although the coverages in space and time are usually too different to permit a mathematical comparison.

19. These researches should be continued to confirm the results but it seems, in the light of this study and other earlier ones executed at Split, that the Adriatic pelagic stocks are characterized by sizeable interannual fluctuations of abundance, in which solar activity is probably a major component.

20. It was stressed that this characteristic did not eliminate the need to seek the best exploitation strategy (with optimization criteria still to be defined). However, in addition to traditional dynamic parameters, it is necessary to study the production variations, analyse them (to separate those related to recruitment from those linked to catchability) and try to predict them. Once this was done, it would still be necessary to establish the best policy for adapting the fleet to these fluctuations; it was suggested that multi-purpose ships would be the best practical solution in the long term.

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1/ These values concern the biomass, not the capturable quantity which is only part of that biomass and is still difficult to determine with present data

State of coastal resources

21. A joint statement was presented by the Italian and Yugoslavian research workers (see Annex G). The results obtained in Yugoslavia by an experimental sampling from 1970 to 1979, employing a trammel net and through analysis of official data, show that the most frequent catch at present (46 percent of the data analysed) is 0.5 kg/net (36 x 1.6 m, or 57 $m^2$), and that average sizes of individuals captured have decreased considerably, as have yields. In general the fishing effort has increased considerably while catches have decreased or remained stationary.

22. It was pointed out that the official statistics are probably greatly underestimated and that the value of coastal fishery landings is actually considerably higher than that of Yugoslavian pelagic and trawl fishery, while its cost of exploitation is low and does not require any subsidy.

23. In Italy the situation appears to be somewhat similar to that of Yugoslavia. It was also pointed out that in this country there are considerable conflicts between coastal and trawl fishery.

24. Following a general discussion, the following aspects of coastal fishery were mentioned:

25. The existing regulations appear to be totally inadequate inasmuch as they have not been able to prevent overfishing.

26. It was pointed out that coastal pollution too is undoubtedly partly responsible for the decrease of yields; this means that the phenomenon could be partly irreversible, even if effort were decreased, without rehabilitation of the coast.

27. It was also stressed that the problem of management of this coastal strip should be considered globally, as that is the way it is presented to the administrators who examine it (comparison of socio-economic or political benefits expected from urbanization, construction of ports, attracting tourists, or conservation of the coastal fishery potential and of artisanal fishery).

28. It was concluded that there was still not a sufficient statistical basis for dealing with this problem (not only in relation to the catch and effort data but also the socio-economic ones). A data collection system based on sampling would have to be set up. In view of the scarce dynamism of this type of fishery, whose evolutions are always very slow, it was even suggested that a permanent sampling programme was not necessarily essential and that a periodic assessment (every three or five years, for example) could be of a type to improve the understanding of the problem at lower cost.

29. A first significant stage could be the execution of an initial assessment, based on surveys, of the whole coastline concerned so as to determine fishing effort (even roughly) and obtain an approximate idea of real catch.

## III. POSSIBILITIES OF REGIONAL COLLABORATION IN THE FIELD OF FISHERY STATISTICS

30. The Yugoslavian officer responsible for agricultural and fishery statistics described the statistical method used to collect catch and effort data. The basis of the system consists of having the masters of trawlers and sailing vessels in the public sector supply daily forms (see Annex H). These forms show the type of fishery, gear characteristics, the place of catch and its quantitative composition by species, day by day. These statistics have existed since 1976 and are reproduced in the Annex.

31. The Institute of Fishery Technology of Ancona presented a statement on the present Italian official fishery statistics collection system, pointing out that all the sources of bias combine to make these data useful elements so far as the national economy is concerned but difficult to use for management of marine biological sources.

32. This part of the exposition was followed by a description of programmes undertaken in the past two years. The first concerns the assessment of catches, fishing effort and population structures of pelagic species in the northern and central Adriatic (see Annex 10 of the Report of the Seventh Session of the GFCM Working Party on Resource Appraisal and Fishery Statistics). The second concerns a frame survey undertaken to evaluate the quality of present statistics on fishing fleets (see Annex I). At the end of 1981 it will be possible to make a quantitative estimate of present catch statistics and, possibly, to correct them by also giving effort statistics. All the elements will then be available for the design and establishment of a general and permanent data collection system if it should prove feasible.

33. During the discussion it was pointed out that the statistical grid design established for this frame survey was selected voluntarily as being compatible with the system used by the Yugoslavian statistical services.

## IV. COLLABORATION IN THE LEGAL SECTOR

34. Although the most recent modifications made by the Italian authorities in their maritime laws could not be analysed, it seemed that the contents of the body of legislation of Italy and Yugoslavia are, on the whole, closely comparable.

35. The Consultation was informed that a new article was under study in Yugoslavia concerning compensation mechanisms in case of injury caused to ocean resources.

36. As harmonized management of common resources involves the existence of systems of law which are compatible on certain points, the need for collaboration in the legislative field was emphasized.

37. The attention of the Consultation was drawn to the report concerning the regulation of fishing effort in the Mediterranean prepared on the initiative of the GFCM. The report points out the need for each country to acquire legal measures which can block an increase of fishing effort effectively.

38. The disturbing problems of the lag between the laws on mesh size and their real application in the region was also raised.

## V. COLLABORATION IN THE FIELD OF AQUACULTURE

39. After a brief outline of the results obtained and the programmes executed by Yugoslavia in this sector, and following a general discussion, it was admitted that there are many aspects on which collaboration at the Adriatic level would be needed, both on technology and on the ecological problems of fish farming environments connected with intensive cultivation techniques, protection of culture sites and exploitation of natural mollusc beds.

40. Consequently the Consultation drew the attention of the GFCM to the usefulness of organizing a subregional *ad hoc* working party in the framework of the GFCM cooperative programme of research on aquaculture on these problems in particular and, more generally, on collaboration on aquaculture matters in the Adriatic.

## VI. ESTABLISHMENT OF A COORDINATED FISHERY RESEARCH PROGRAMME IN THE ADRIATIC AND RECOMMENDATIONS

41. Throughout the discussion a consensus emerged clearly concerning the objective of the research undertaken or to be undertaken, and the methods and resources to be applied in order to attain that objective.

42. This consensus means that an implicit but unstated common research programme already exists, which would gain by being formulated to act as:

on one hand, a general framework for subregional collaboration to channel the effect of each participant in a common direction;

on the other hand, as an embryo for the eventual establishment, within the framework of the GFCM, of a real regional resource appraisal and management programme for which there is a felt need.

43. The characteristics of this programme would be:

TITLE OF THE PROGRAMME

The study of Adriatic biological resources with a view to their optimum exploitation through rational management

OBJECTIVES OF THE PROGRAMME

To provide the competent authorities with all the statistical and biological data necessary for the establishment of a rational exploitation policy

To supply the data making it possible in the long term to conduct exploitation of resources of common interest coordinated at the subregional level

Monitor the state of stocks to assure their conservation and assess the real consequences of proposed or applied management measures

RESEARCH PROJECTS

Several actions are envisaged to attain these objectives:

(i) Establishment of feasible systems of statistical (catch, effort) and biological (measurements) data collection on catches obtained by the exploitation systems (industrial or artisanal);

(ii) Establishment of procedures for follow-up of the state of resources through direct methods (surveys on eggs and larvae, eco-surveys, periodic trawl surveys);

(iii) Intensification of scientific collaboration at the subregional level through the establishment of direct and frequent contacts between scientists, harmonization of work methods, coordination of cruises, etc.;

(iv) Synthesis of available data for better use of information;

(v) Harmonization of regulations with a view to coordinated management at the regional level.

For the sound operation of the programme and, in particular, to accelerate progress obtained until now in resource appraisal and the establishment of optimum exploitation conditions, several recommendations concerning the research projects i to v were formulated and will be submitted for approval to the Fifteenth Session of the General Fisheries Council for the Mediterranean.

44. These recommendations are as follows:

Recommendation I

Recognizing that information on the state of resources and the effectiveness of management measures deriving from it depends on the quality of available statistics, the First Technical Consultation on Stock Assessment in the Adriatic recommends that serious consideration be given to the need for setting up a catch and fishing effort statistics collection system covering all fishery activities as far as possible, or for strengthening it where it already exists,

draws attention to the results of the feasibility study undertaken in Italy on the system for catch and effort statistics collection through sampling of commercial fishery, which could be of interest in fishery of the private sector or coastal exploitation in Yugoslavia,

recommends that the officers responsible for fishery statistics of the countries concerned maintain direct, close, and frequent contact in order to keep themselves informed of the reciprocal progress obtained in this field and eventually to design and set up compatible data collection and treatment systems.

Recommendation II

In view of the grave lack of information on the population structure of demersal catches of the Adriatic, considering the need for assessments by direct methods (eggs and larvae, eco-surveys, trawling) so as to have detailed data on catch structure for optimization of results,

the First Technical Consultation on Stock Assessment in the Adriatic strongly recommends the establishment of a sampling network in the main landing ports and, eventually, on fishing vessels themselves to obtain size and age structures of the species captured.

Recommendation III

Since it is impossible at present to give the limits of reliability of evaluations of potential by traditional methods where the risk of error is high, it is advisable to promote all methods of a nature that can provide an image of the state of stocks directly, while waiting until the improvement of statistical networks enable to better discern the relationship between these stocks and exploitation. Consequently, the First Technical Consultation on Stock Assessment in the Adriatic

recommends that direct appraisal methods not only be continued but also coordinated at the subregional level and intensified to give them the geographic coverage and quantity of findings necessary for more accurate quantification of the factors measured (densities, biomass, compositions, etc.).

It recommends, in particular, the establishment of joint geographic observation areas to permit increased accuracy of appraisals through comparison of the results obtained by the different methods.

Recommendation IV

Considering the importance of direct acoustic assessment methods and the need to substantially increase subregional cooperation in this field, the First Technical Consultation on Stock Assessment in the Adriatic

recommends

- the execution of experiments - which have been programmed for a long time - in electronic intercalibration between the acoustic equipment of different laboratories, and hopes that the administrative problems impeding the execution of this experience - which is fundamental for future progress - can be solved;

- harmonization of echogramme analysis methods;

- harmonization of cruise plans and sampling strategies.

Recommendation V

Recognizing the need to intensify part of the research work along a few preferred lines of a character permitting substantial progress of information, the First Consultation on Stock Assessment in the Adriatic

recommends that studies be accelerated and that the results concerning in particular:

- adult mortality of the main pelagic stocks (sardines, anchovy);

- larval and postlarval mortality;

- long-term fluctuations in production of pelagic stocks of the Adriatic

be made available to the Working Party on Resource Appraisal and Fishery Statistics and to scientific institutes of the subregion.

Recommendation VI

Faced with the need for regular follow-up of the progress achieved in the different sectors of fishery research and to promote a fruitful policy for the exchange of information and pooling of scientific capacities,

feeling that only the acquiring by the parties concerned of a common view of resources and a shared understanding of the mechanisms governing them can lead, in the long term to the success of concerted exploitation and management of resources of common interest,

convinced that the establishment of a real, permanent concertation mechanism at the sub-regional level is of a character to lead the countries of the subregion most rapidly to that common view, promote the practical implementation of the recommendations on appraisal made by the GFCM Working Party on Resource Appraisal and Fishery Statistics, and identify the problems of a subregional character which deserve to be brought to its attention, the First Technical Consultation on Stock Assessment in the Adriatic

hopes that such consultations will be organized periodically and regularly in order to:

- periodically update statistics and data on stocks;

- refine the available assessments through use of the new elements of information obtained;

- propose management schemes.

Recommendation VII

Having recognized that the statistical basis of the available data for assessment of demersal stock potential and definition of optimum exploitation conditions is insufficient at present,

having also recognized that the biological data on the biotopes and species exploited have been very abundant but were not available in readily usable form,

the First Technical Consultation on Stock Assessment in the Adriatic

recommends the compilation of a biological data base containing the most relevant information for resources assessment, containing the necessary descriptive elements of the environment and the main biological parameters of the leading exploited species.

The list of elements to be assembled and the name of the officers or institutions in charge of their compilation are given below:

| Descriptive features of the environment | Officers responsible[2] |
|---|---|
| - bathymetric map[1] | IOR/I.G.Mar. |
| - sedimentological map[1] | IOR/I.G.Mar. |
| - map of biocenoses[1] | IOR |
| - fish communities map[1] | |
| - references on hydrological description | LBRM/IOR |
| - catalogue of selected data on the hydrological reference stations, rainfall, flow rate of main rivers, abundance of plancton, etc. | LBMP/IOR |
| **Main biological parameters** | |
| Main demersal species exploited: | |
| - *Gadus capelanus* | ITP (Froglia) |
| - *Merluccius merluccius* | IOR (Jukić/Zupanović) |
| - *Solea solea* | LBMP (Pagotto) |
| - *Mullus barbatus* | IOR (Jukić)/LBMP (Piccinetti) |
| - *Pagellus erythrinus* | IOR (Jukić) |
| - *Trachurus trachurus* | IOR (Hernandez) |
| - *Nephrops norvegicus* | MSU (Crnković)/ITP (Froglia) |
| - *Squilla mantis* | LBMP (Mrs Piccinetti) |
| - *Loligo vulgaris* | IOR (Gamulin-Brida) |
| - *Sepia officinalis* | IOR (Gamulin-Brida)/ MSU (Legać) |
| - *Eledone moscata* | IOR (Gamulin-Brida)/ MSU (Legać) |
| and the group of cartilaginous fishes (*Scyliorhinus* spp., *Mustelus* spp., *Squalus* spp., and rajidae) | IOR (Jardas) |

The items to be assembled concern:

- distribution
- migrations
- inventory of available size frequencies
- growth
- reproduction (fertility, spawning season, age of first mass spawning)

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1/ Although many maps are available it will be necessary to make a comprehensive summary map

2/ IOR = Institut za oceanografiju i ribarstvo, Split
ITP = Istituto di Tecnologia della Pesca, Ancona
I.G.Mar. = Istituto di Geologia Marina, Bologna
MSU = Musée de sciences naturelles, Rijeka
LBMP = Laboratorio di Biologia Marina e Pesca, Fano

- length/weight relationship
- total length/fork length relationship
- selectivity
- mortality
- evaluation of production.

The reciprocal responsibilities for the execution of this important study were distributed according to the competences and availabilities of the subregion. The responsible officer appointed will be assigned to prepare an initial document which will be sent to other laboratories of the subregion for eventual supplementary information, and to the Secretariat of the GFCM. The deadline for delivery of the document is the end of 1980, and the final document should be ready for the Second Technical Consultation on Stock Assessment in the Adriatic which could be held in May 1981 in Ancona.

For presentation of data, one will refer to the study by P.-Y. Dremière published as an annex to the report of the Technical Consultation for Stock Assessment in the Balearic and Gulf of Lions statistical divisions (FAO Fisheries Report No. 227).

Recommendation VIII

In regard to protection and management of fishery resources of the Adriatic, it is necessary to plan the harmonization of the legal regulations already existing at the regional level, and the establishment of new regulations.

The First Technical Consultation on Stock Assessment in the Adriatic therefore recommends that a team of legal experts meet regularly to work on this question and to follow the implementation of measures proposed both at the national and at the subregional level.

## VII. DATE AND PLACE OF THE NEXT CONSULTATION

45. As indicated in Recommendation VII, it was suggested that the next Consultation take place in May 1981, in Ancona.

## VIII. ADOPTION OF THE REPORT

46. The Report of the First Technical Consultation on Stock Assessment in the Adriatic was approved on 6 June 1980.

Annex A

AGENDA

1. Opening of the Consultation

2. Election of the Chairman

3. Adoption of the Agenda

4. Importance of scientific assessment of stocks, management, and of protective measures in the Mediterranean, particularly in the Adriatic

5. Description of the main fisheries in the Adriatic

   5.1 State of demersal stocks

   5.2 State of pelagic stocks

   5.3 State of stocks of coastal resources

6. Possibilities for regional collaboration in the field of fishery statistics

7. Possibilities of regional collaboration in the fields of scientific research and management

8. Possibilities for scientific collaboration in the field of legislation on stock protection within the framework of the GFCM recommendations

9. Possibilities for regional collaboration in the field of mariculture

10. Date and place of the next Consultation

11. Adoption of the report

## Annex B

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Annex C

# ADRIATIC DEMERSAL RESOURCES/RESSOURCES DEMERSALES DE L'ADRIATIQUE

by/par

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## I. BACKGROUND

### 1. Yugoslavia

The general characteristics of the Yugoslav commercial fishing operations which have been carried out mostly within the coastal and territorial waters since the end of the second world war are as follows:

The total number of boats in the commercial fleet, mostly seiner-trawler type, up to 1960 was 211. At present the social (as opposed to "private") sector owns 166 units and the private sector 71, generally with a very high percentage of writ-off value.

The total number of fishermen is 2 140 (full-time employed) and 9 372 (part-time employed).

The total yearly production in the Adriatic after the second world war is twice the production before the war but is still fairly low as compared to market demands. The maximum yield (37 465 t) was achieved in 1978 from which 29 712 t were landings of small pelagic species (sardine, anchovy, sprat), 1 134 t of tuna, 1 876 t of demersal species. Mariculture (oysters, mussels) production was 400 t and the balance came from coastal fisheries.

Because of the small number and age of the commercial fleet an increase of fishing activities in the Adriatic through the construction of new units and reconstruction of old ones for a higher production, has a significant, potential position in the national economy.

During 1948/49 the HVAR trawl survey expedition was undertaken by the Institute for Oceanography and Fisheries in Split for demersal resources over the Adriatic continental shelf. Special attention was devoted to studies on the quantitative and qualitative population aspects, i.e., abundance of fish, cephalopods and crustaceans owing to the various biocoenosis of the littoral Adriatic zones.

Since that time in the framework of the national research programmes, mostly along the eastern Adriatic coast, studies such as: taxonomy, biology, idio-ecology, population dynamics were carried out. With regard to demersal and semi-demersal populations dynamics studies a certain number of preliminary conclusions were reached. For instance, for the striped mullet (Mullus barbatus L.) population in the central Adriatic (Zeid, 1970) the total coefficient of population mortality was Z = 0.64. In the case of pandora (Pagellus erythrinus L.) the population along the eastern Adriatic coast mortality coefficient was Z = 1.50. For the hake (Merlucciius merluccius L.) population in the open central Adriatic (Zupanović, 1968), the calculated mortality coefficient was Z = 0.79.

Studies of length frequency distribution of the species of Chondrichthyes fish such as: Scyliorhinus, Mustellus and Rajidae (Jardas, 1979) have pointed out disappearance of larger and older fish.

Intensive food and feeding habits studies of demersal fish population along the eastern Adriatic coast were carried out (Jukić, 1965; 1974) for Mullus barbatus, Pagellus erythrinus, Boops boops and Merluccius merluccius.

Partial assessment of pelagic and demersal resources along the eastern coast has been given by Županović (1964).

Trawl selectivity studies for: Merluccius merluccius, Pagellus erythrinus, Mullus barbatus, Trachurus trachurus and Nephrops norvegicus in the central Adriatic were carried out (Jukić, 1974).

Quite recently (Alegria Hernandez and Jukić, 1980 MS) the possibility for application of global linear and exponential productive Schaefer's and Fox's models for sardine populations along the eastern Adriatic coast has been pointed out.

## 2. Italie

La pêche démersale est pratiquée en Italie depuis des siècles et, au moins pour ce qui concerne le dernier siècle elle est effectuée d'une façon intensive le long des côtes et en mer ouverte dans toute la haute et la moyenne Adriatique.

Le nombre total des bateaux à moteur de pêche commerciale était en décembre 1977 de 5 724 avec une puissance totale de 351 732 ch. Les pêcheurs professionnels sur ces bateaux étaient 13 968. L'importance de la pêche sportive, active le long des côtes, n'est pas facilement évaluable en quantité.

Les types de pêche exercés par les bateaux à moteur sont très nombreux et souvent il y a des passages d'un jour à l'autre entre différents types de pêche (par exemple, du chalutage démersal au chalutage pélagique, du chalutage côtier au chalutage au large) et il n'existe pas de données fiables sur une répartition des bateaux par engin de pêche ou par zone de pêche.

Les captures totales, telles qu'elles sont reportées dans les statistiques officielles ne sont pas, pour plusieurs raisons, utilisables pour les évaluations des ressources, tant en ce qui concerne les quantités totales que la répartition par espèces. A titre indicatif on signale que les captures totales de 1977 pour la haute et la moyenne Adriatique, rapportées dans le livre des statistiques officielles italiennes sont de 137 398 t dont environ 80 000 t pourraient être des espèces démersales. Les captures réelles sont bien supérieures.

L'orientation actuelle en Italie est de ne pas inciter à la construction de nouveaux chalutiers; on a également commencé pour quelques types de pêche (par exemple: chalutage côtier, pêche des coquillages) à instituer dans la pratique un système de licences qui tend à limiter toute augmentation de l'effort de pêche. Parallèlement on a limité fortement le potentiel de captures par la pêche sportive.

Les nombreuses recherches faites au cours de plusieurs dizaines d'années d'activité de différents laboratoires italiens de l'Adriatique n'ont souvent pas été coordonnées entre elles et ont rarement été orientées dans un but d'évaluation des ressources. On dispose de nombreuses données sur les paramètres du milieu et sur la biologie générale, mais il y a très peu d'investigations utilisables dans une optique de dynamique de populations.

Les analyses sur les captures montrent que, sur un total de plus de 50 espèces démersales d'intérêt commercial capturées, la plupart sont de petite taille, avec une vie très courte et qui atteignent souvent la maturité sexuelle massive à 1 ou 2 ans. Ces espèces présentent souvent des fluctuations interannuelles d'abondance très marquées qui semblent être indépendantes de l'activité de pêche.

La composition des captures par espèce varie d'une zone à l'autre et d'une saison à l'autre dans la même région. L'absence d'espèces prédominantes dans les captures démersales et les considérations précédentes rendent très difficile l'analyse et l'aménagement des stocks.

Des recherches sur la technologie de quelques engins de pêche et sur la sélectivité du chalut vis-à-vis des principales espèces démersales ont été réalisées.

Les effets du chalutage dans la zone côtière ont été étudiés dans différentes zones de l'Adriatique.

Des études sur la répartition par taille des principales espèces démersales dans différentes zones sont en cours.

Une enquête par échantillonnage a été commencée pour déterminer les prises réelles des chalutiers et l'effort de pêche.

## II. ITALO-YUGOSLAV COOPERATIVE PROGRAMME

### 1. General Considerations

It might be said that fishery studies undertaken either by Yugoslavian or Italian scientists in the Adriatic during the post-war period were mostly and generally restricted to local trawl fishing grounds where the fundamental ichthyological studies predominated over the modern quantitative approaches and methodologies and, as a result of such a situation it is not difficult in the Adriatic to find out that empirical statements of the size of the main stocks may wrongly influence national fisheries policies which generally tend to increase fishing activities, neglecting essential parameters such as resource stock size, maximum sustainable biological and economic yields.

On the basis of available statistics data of total yearly yields of Italian and Yugoslav trawlers and fishing effort expressed in the form of GRT for statistical area 37.4, it seems according to the conclusions of the GFCM Working Party on Resource Appraisal and Fishery Statistics that production might be increased from 10 to 25% with corresponding increase of fishing effort from 33 to 100%, i.e., sustainable trawl yields in the Adriatic might amount to between 73 000 and 83 000 t. This conclusion, undoubtedly, should be carefully considered owing to the lack of good and reliable statistical data, especially as far as fishing effort data are concerned.

Present situation might be made more complicated by the recently agreed exclusive fishing zones policy. Owing to these facts, improvement of cooperative research programmes has been needed in the Adriatic where increased knowledge of the present status of the demersal stocks and potential yields is essential for a better planning of fisheries policy.

### 2. Present Results of the Italo-Yugoslav Cooperation

With regard to the cooperative programme between the Institute of Oceanography and Fisheries in Split and the Laboratorio di Biologia e di Pesca, Fano, trawl surveys on the profile from Fano (Italian territorial waters) were carried out in 1973 for assessment of quantitative and qualitative aspects of trawl fishing grounds.

During 1974 comparative studies of economic aspects, cost/benefit relationships of the trawl fishing operations inside territorial waters of Yugoslavia were undertaken. On the basis of collected data (Jukić and Piccinetti, 1979) inside Yugoslav territorial waters in the northern Adriatic, evaluation of demersal Standing Stock Size and Maximum Sustainable Yield forecast was roughly assessed.

In 1975 a series of experimental trawlings were carried out in 15 stations of the northern and central Adriatic with determination of the species caught, yields and size frequencies for the economically interesting species.

3. Proposals for a Future Cooperative Programme

The following tasks should be improved through demersal resources monitoring programmes:

(a) Permanent trawl surveys over the Adriatic continental shelf by means of which demersal stock abundance, in time and space, should be assessed. Such surveys should also consider biological aspects of the main commercial populations;

(b) Creation of a sub-regional expert group for evaluation in the Adriatic where quotas and fishing strategy should be treated like in the other fishing areas where global production models (Schaefer, Fox) are bases for management.

In correlation with this programme, better fisheries statistics are needed as well as commercial catch analysis.

Annex D

# PELAGIC FISH IN THE ADRIATIC - DISTRIBUTION AND STOCK ASSESSMENT

by

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## 1. INTRODUCTION

Small pelagic fish including sardine (Sardina pilchardus Walb.), anchovy (Engraulis encrasicolus L.) and sprat (Sprattus sprattus L.) make up the principal proportion of the living resources of the Adriatic Sea. Among these, sardines are most important since their contribution amounts to 60% of the total catch. There is a vast number of published studies on their fish distribution. They considerably contribute to our knowledge of the life of these fish species. We are going to mention some of them.

## 2. DISTRIBUTION OF PELAGIC FISH IN THE ADRIATIC

It was found that sardine and anchovy are distributed in the whole area of the Adriatic Sea, but with considerable variations in time and space. Sprat is mainly distributed in the north Adriatic. Its area of distribution is pretty limited.

### Sardine

As mentioned above sardine is distributed in almost the whole area of the Adriatic with the exception of its deepest parts (south Adriatic valley and the valley of the Jabuka island). Younger groups of sardine, mostly those not older than 1 year of age inhabit coves and gulfs where they can find a kind of natural shelter, and, important to mention, enough food. They are distributed in the area from the coasts of Montenegro to the waters of Istria, until the time of the first sexual maturity. They like to inhabit the gulfs when they migrate to deeper open waters toward the spawning place.

Adult sardine groups also inhabit the area from the Montenegrian coast to the Gulf of Trieste. There we can find several focuses of distribution (centres of populative gravitation) which are tightly connected with environmental factors. Until now following focuses and areas of sardine distribution have been known.

Area of oligotrophic eastern waters of the north Adriatic from Dugi Otok to the Gulf of Trieste which during the whole year points to the following.

During the summer period and till late autumn the greatest part of the sardine population inhabit the area of western coast of Istria and the Gulf of Trieste.

When during the autumn months the sea temperature drops below 16°C, sardine begin to migrate toward the southern parts of the eastern Adriatic, so that the greatest part of the northern subpopulation of sardine stabilizes in the open area from Susak to Dugi Otok at the depth which ranges from 60 to 80 m. Simultaneously with the migration of this subpopulation of sardine spawning period begins which is most intensive in the open area of Dugi Otok (Štirn and Kubik, 1974).

Autumn-winter sardine migration toward the south is very often intensive, directed and quick, while just the opposite happens with the spring migration. This migration toward the waters of Istria is much slower, difuse and in some years rather irregular. Sardine subpopulations of the northern and the southern part of the Adriatic sea do not seem to mix

with each other, for a continuous link between the focuses of their distribution has not been found. South sardine subpopulation is distributed during the greater part of the year more or less in the whole area, in fact in the area closer to the coast, in canals and in the open waters of the Adriatic sea. One of the limiting factors of distribution are the depths above 100 m. During the winter months focuses of sardine distribution in the middle Adriatic move toward the outer islands of Vis, Bisevo and Palagruza where they spawn.

Anchovy

Anchovy are more distinctive open sea fish than sardine. But all the same we come across them also in coves and gulfs from the coast of Montenegro to the Gulf of Trieste. We must also point out that they can be found during all seasons. However, it must be said that anchovy as neritic fish always inhabit the shallowest and the most eutrophic waters of the northern Adriatic, approximately north and west from the isobath of 50 m. During colder periods of the year when they are not spawning anchovy are distributed in that region rather homogeneously and dispersively. At the beginning of the spawning period during the early summer schools of anchovy begin to concentrate more intensively and they fill all the areas, especially those not inhabited by sardine. So that in northern Adriatic during the summer period the anchovy population is forced to migrate in "circles" and the reason for that is maybe their competition for the space with sardine. This migration shows a trend of summer distribution of anchovy. That is the reason why during the most intensive spawning period (July, September) a great part of the anchovy population is concentrated in neritic waters closer to the Italian part in the region from the mouth of the Po river toward Ancona.

Generally speaking, anchovy which inhabit the Adriatic tend to move in circles by the eastern Adriatic coast up to the utmost northern part in the spring, and then they continue their circulation closer to the Italian coast toward the south in winter (Piccinetti, 1970). It should be stressed that a part of the anchovy population is during the whole year distributed in the greater part of the Adriatic, which is also shown by the catch statistics.

Sprat

Sprat, contrary to sardine and anchovy, are distributed mostly in the shallow waters of the northern Adriatic by the Italian coast up to Rimini, and also in the Gulf of Kvarner. They inhabit the areas which abound in surface or submarine flows or fresh waters where the sea salinity is to a certain extent reduced. Besides, winter temperatures of the sea are a little bit lower in those regions and favourable for sprat reproduction. In fact, by their origin sprat are boreal species. Geographic isolation of sprat population caused the development of several characteristic varieties of that species (Zavodnik, 1974).

In summer periods we come across the biggest concentrations of sprat in the middle and the western part of the Gulf of Venice, where the fish stay mostly in deeper and colder sea layers, in fact below termoclina. Together with the appearance of homotermi in the late autumn, a part of their population begin to move toward the south up to Rimini, while the other part move more toward west Istria, then they go along its coast toward the south and reach the Kvarner island area and the Gulf of Rijeka. In summer a part of the Kvarner stock move in the deep, but it seems that the sprat schools again turn back to the open waters of the Gulf of Venice (Zavodnik, 1974).

According to existing data, north Adriatic sprat do not seem to live more than five years, during which period they reach 15 cm in length.

Fluctuations of sardine, anchovy and sprat in the Adriatic appear to be very large. (The catches were extremely poor in some years.) Our investigations therefore gave particular attention to this problem. The causes likely to affect either the increase or the reduction of fish stocks were studied. Thus biotic and abiotic factors were correlated, i.e., everything from the food chains to the air pressure and stronger or smaller ingression of the Mediterranean water in the Adriatic.

It would be pretty difficult to bring out all the factors which have been studied in order to account for the regularities of small pelagic fish fluctuations.

The above-mentioned studies threw some light on the distribution of these three commercially important fish species.

In the last few years the investigations carried out by hydroacoustic methods add to the knowledge of these species.

Since the methods of echo survey are of a particular importance for us they will be described in more detail. Several stages of work may be distinguished here.

Having in mind the knowledge of the behaviour, distribution and fluctuations of these three fish species, first stage of work with electroacoustic instruments included the testing of the known regularities or achieving the new ones.

Very valuable data on fish behaviour by day and by night were obtained. However, we concluded that it would be more appropriate and real to carry out the echo-sounding during the daylight. The theory that sardine migrations toward the open sea in the course of the year independent of the increase or decrease in the sea temperature was also confirmed.

The data on the possible school size with respect to sea depth and the age of fish were obtained.

The vertical migrations of fish with respect to the time of the day were also observed.

We succeded however roughly to follow the number of fish concentrations from year to year. This was the first step in the studies of relative fish abundance.

Yugoslavia has fairly developed industry for processing small pelagic fish. This industry naturally intensifies its demands for resources from year to year. Since, however, these resources (fish) are liable to fluctuations and migrations it happened that in some seasons (particularly in the winter) and even during the whole of some years these factories, which also have their fishing fleets, did not obtain sufficient quantity of fish. Therefore, signing a contract with fisheries organizations and fish processing factories we started an applicative survey based on the earlier investigations and achievements, and fish behaviour studies by acoustic methods.

The echo survey was carried out on a monthly basis. We surveyed all the parameters relevant to fisheries organizations dealing with the small pelagic fish catching.

Fish was identified by means of a pelagic net. Charts were made according to the records of fish distribution by density and species. We kept informing fisheries organizations, sending them charts so that they might send the parts of their fleets to these sites.

The following data were obtained by these echo surveys. Sardine were recorded even from the northern Adriatic in the winter, except for its small northernmost part. This species was formerly not thought to inhabit the northern Adriatic during the cold period.

Sprat were found in the eastern Adriatic in the spring and summer. It had been thought before that they left these areas in the summer. A total of 4 055 n mi was crossed by echo survey. The average number of fish concentrations per mile of the crossed path of vessel's motion ($\bar{X}/M$) was also computed. It proved to be a good indicator of the relative fish abundance. The comparison of the echo survey results of 1974 with those of 1975 showed that the number of small pelagic fish concentrations per unit of the crossed path was slightly changed, mainly in the northern Adriatic.

The distribution of sardine, anchovy, and sprat concentrations pointed to the existence of three principal fishing areas. The knowledge of this distribution would render possible an optimum selection of sites for the erection of fish product factories.

Described method of echo survey (echo monitoring) is very useful and should not be neglected.

3. STOCK ESTIMATION

Estimation of small pelagic fish amounts has been carried out by different methods. Each of those methods can in certain favourable circumstances give relatively exact estimations of fish biomass.

However, all of them have their specific sources of possible mistakes, so that results could be obtained which differ greatly from the real situation.

The best results are obtained by simultaneous assessment using two or more methods. It was on the basis of different methods that biomasses for small pelagic fish were estimated. Sometimes the stock for specific species was estimated separately and sometimes for all three species together.

It was estimated that about 75% of the total of small pelagic fish (sardine, anchovy, sprat) which inhabit the Adriatic are found along the line which connects the cape of the island Dugi Otok and Porto d'Ascoli on the Italian coast. This estimation showed that sardine and anchovy production may increase to the level of about 500 000 t in years of high production (rich years) and of about 220 000 t in years of low production (poor years). Sprat quantity in the Adriatic was computed to be about 100 000 t. It should be emphasized that these figures are likely to fluctuate a lot, particularly in years of the so-called "low bioproduction". There is a number of factors, such as natural mortality fishing, predators, etc., which reduce the stock of these fishes to a certain extent. Therefore, it would be necessary to perform continuous year-to-year observation applying different methods.

Direct measurement of quantity by means of echointegrator is one of these methods. It is particularly appropriate for the fish concentrations of greater densities. This method is now widely applied even though it has recently been seriously approached.

There is no need to describe this method here.

By this method we calculated sardine and anchovy stocks to be 122 527 t for the part of the middle and north Adriatic which covers the area of 6 235 $km^2$. Echo survey in 1979 gave slightly worse results for the same area. We should stress that dealing with these estimations we used the integration constant obtained by the experiments performed near Ancona and Fano in 1975 and that some mistakes in the estimations are possible.

The Problem of Fish Identification and the Stock Estimation in "Mixed" Populations

Identification of individual pelagic fish species in the so-called "mixed" populations is very difficult to carry out especially in the north Adriatic where sometimes all three species are found together at the same time. As mentioned above, there is a kind of border among them and each species has its own focus of distribution, but sometimes it is not shown. Identification can be carried out in two ways: using pelagic trawl or analysing echogram, which shows to be rather effective and exact. It was noticed that in certain periods different species appear in different depths. The example can be the fact that during the summer period sprat appear to be at the very bottom, in colder sea region, making "layers" of irregular shape, then that the sardine concentrations have mostly the usual "fingerlike" shape, and that anchovy most frequently inhabit the area closer to the sea surface, and the shape of their school is rather irregular on the echogram. This rather varies in colder periods during homotermi when the sprat concentrations rise from the sea bottom and come close to the coast of Istria and Kvarner, and sardine together with anchovy are still present in those waters. Stratification of the population "in layers" disappears, and to some extent horizontal

bordersamong the species. Here appears the problem of calculating the stock of these individual species by means of echointegrator. It is difficult to establish how many microVolts come to some species on integram. There is also to establish the kind of constant (C) for sardine, especially for anchovy and of sprat, which seems to be a great problem. Maybe the Lamboeuf, Stepnovski and Brethes (1976-1977) method should be used. They introduced in Morocco two constants: they used the first constant for the sardine stock north of C. Blanc, and the second for the southern area.

As far as our joint research on pelagic fish of the Adriatic is concerned, we should cooperate more in resolving a series of problems. These fish populations are joint, so we should jointly work in the research of the behaviour, distribution and the stock assessment of their settlements for, all the time we talk of one single population, disregarding the fact who, at present, use this more. We should solve these problems together, and that is why we have brought out a joint programme which must be discussed and about which context you will be informed in time.

In conclusion:

Sardine, anchovy and sprat make up the biggest part of small pelagic fish population in the Adriatic;

By the calculations obtained by different methods it is obvious that the stock of the mentioned species is considerably great and that it allows sustainable yield in the period of high bioproduction in the Adriatic;

There is a need to coordinate the work on the stock assessment between Yugoslav and Italian scientists;

The methods of the research should be unified;

A permanent work group consisting of Yugoslav and Italian scientists should be formed which would observe the changes in size of pelagic fish settlements and which would give certain suggestions on the governing of the joint pelagic fish resources of the Adriatic.

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Table 1

Abundance of small pelagic fish (the number of fish concentrations) during cruising in 1974 and 1975. (Max/M = maximal number of concentrations, $\bar{X}$/M = average number of concentrations per mile of the crossed path

| Area of research | Miles crossed | Number of fish concentrations | | | | Abundancy | |
|---|---|---|---|---|---|---|---|
| | | I | II | III | T | Max/M | $\bar{X}$/M |
| Middle Adriatic | 1 704 | 856 | 187 | 78 | 1 121 | 3.1 | 0.68 |
| North Adriatic | 2 351 | 2 274 | 881 | 465 | 3 620 | 5.4 | 1.58 |
| Total | 4 055 | 3 130 | 1 068 | 543 | 4 741 | 4.3 | 1.13 |

Table 2

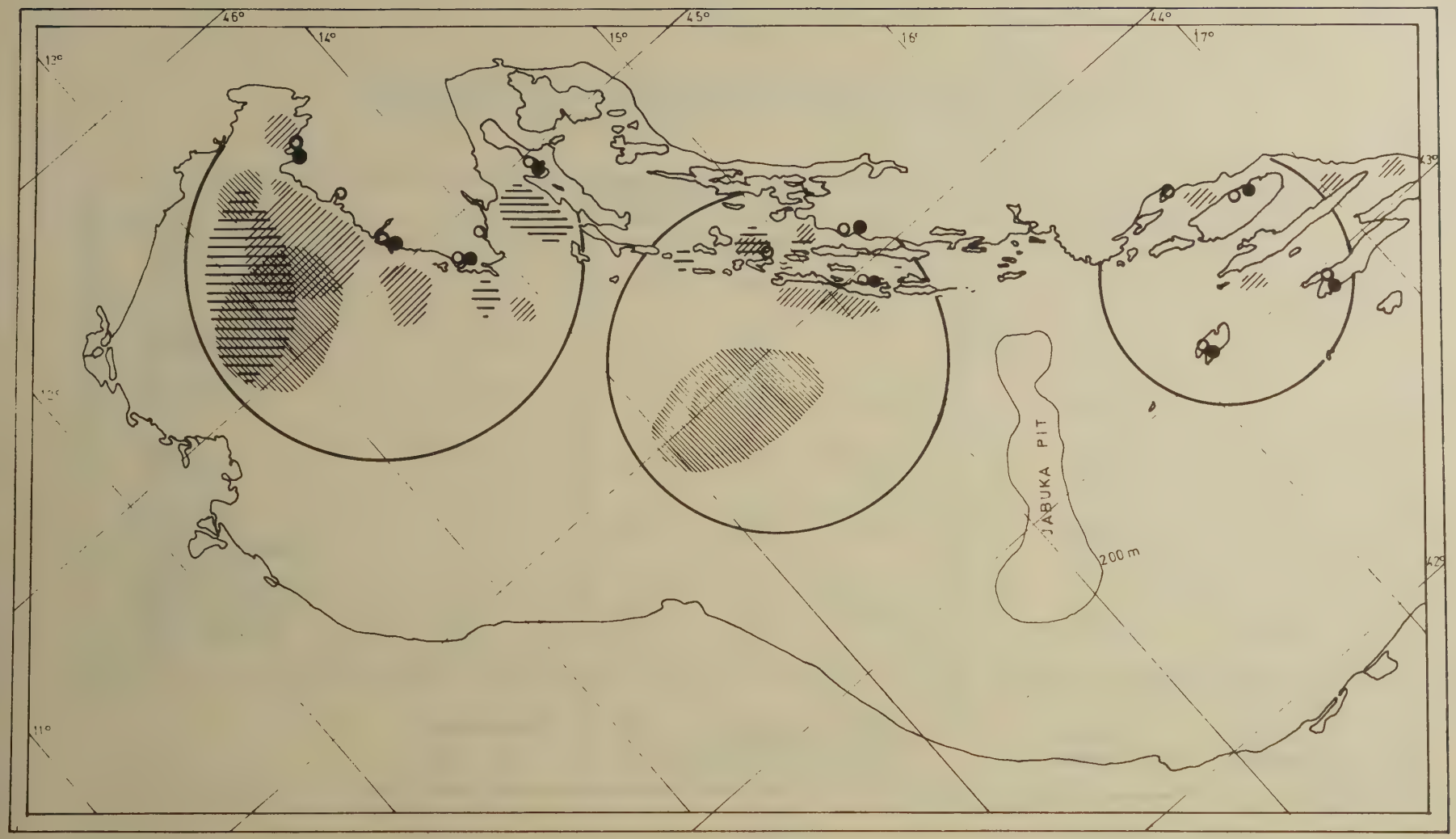
Distribution and abundance of pelagic fish in the Middle and North Adriatic during July and August 1977. The data are obtained by means of scientific sounder and echointegrator (mV/mm Nm)

| Area of research | Miles crossed | Echointegrator sayings canals | | | | | | Fish species | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A | | B | | T | $\bar{X}$ | | | |
| | | T | $\bar{X}$ | T | $\bar{X}$ | (AB) | (AB) | Sardine | Anchovy | Sprat |
| Kornati Ist | 42 | 11.5 | 0.27 | 25.2 | 0.60 | 36.7 | 0.87 | + | + | |
| Ist Pula | 65 | 5.0 | 0.08 | 51.5 | 0.79 | 56.5 | 0.87 | + | + | + |
| Pula Novigrad | 53 | 45.0 | 0.85 | 98.0 | 1.85 | 143.0 | 2.70 | + | + | + |
| Novigrad Koper | 41 | 72.5 | 1.77 | 82.0 | 2.00 | 154.5 | 3.77 | + | + | |
| Total | 201 | 134.0 | 0.67 | 256.7 | 1.28 | 390.7 | 1.94 | | | |

Table 3

Quantity and density of small pelagic fish obtained by scientific sounder and echointegrator in the Middle and North Adriatic at the end of July and the beginning of August 1977

| | $Km^2$ (S) researched | Echointegrator (mV mm/Nm) canals | | | Density ($\bar{d}$) $T/Nm^2$ | Weight (W) in tons |
|---|---|---|---|---|---|---|
| | | A | B | (A+B) | | |
| Brac Channel<br>Hvar Channel<br>Neretva Channel | 676 | 0.34 | 3.40 | 3.73 | 68.5 | 24 983 |
| Korcula Channel<br>Pelegrin<br>Primosten | 917 | 0.28 | 1.01 | 1.29 | 23.7 | 11 718 |
| Kornati<br>Porer | 2 472 | 0.15 | 0.72 | 0.87 | 16.0 | 21 313 |
| Porer<br>Novigrad | 1 174 | 0.85 | 1.85 | 2.70 | 50.0 | 31 412 |
| Novigrad<br>Gulf of Triest | 650 | 1.77 | 2.00 | 3.77 | 69.0 | 24 282 |
| Porer<br>Kvarner | 346 | 0.33 | 2.24 | 2.57 | 47.0 | 8 819 |
| Total | 6 235 | 0.62 | 1.87 | 2.48 | 45.7 | 122 527 |




SARDINE

ANCHOVY

SPRAT

FISHING PORTS AND BOATS

FISH FACTORIES

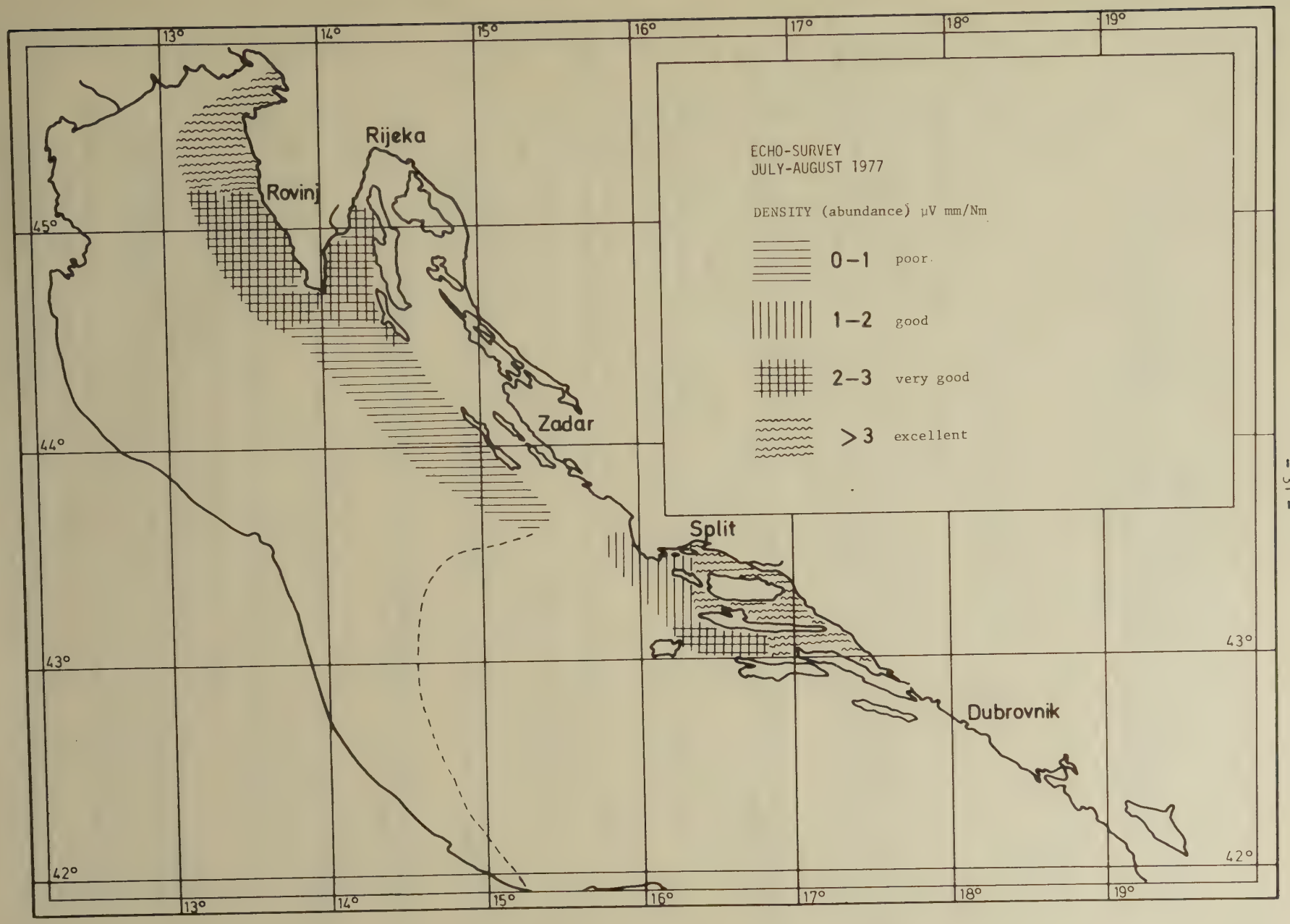



Fig. 4 Abundance of fish calculated by Scientific Sounder and Echointegrator (July-August, 1977)

Annex E

# SUMMARY OF THE RESULTS OF THE RESEARCH PROJECT "EVALUATION OF PELAGIC RESOURCES USING ELECTROACOUSTIC INSTRUMENTS" FROM 1975 TO 1980

by

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## 1. OBJECTIVES OF THE RESEARCH PROJECT

The evaluation of pelagic stocks using electroacoustic methods should be understood as a multi-purpose project because the potential uses of the results of acoustic surveys repeated in the same area are of interest to managers of fishing activities as well as to producers and buyers, biologists and oceanographers, and also electronic engineers who are interested in the system of collecting and processing the data.

The primary purpose of this research has been to respond promptly and reliably to some questions essential to the correct management of fish resources, specifically:

Where (by species) are the pelagic resources distributed?

What is their density, in tons, and how has this varied in recent years?

What is the optimum utilization of these resources?

In any case, potentially through this research a variety of other results can be obtained which are of considerable interest to many fields. These results include:

(a) Relative and absolute estimates of the density and variability in time of an entire population, any sub-population, and classes by age/size;

(b) Geographic distribution and the variability of these parameters in time (migrations) of an entire population, any sub-population, and classes by age/size;

(c) Vertical distribution and variability of these parameters in time (daily migrations) of an entire population, any sub-population, and classes by age/size;

(d) Comparisons with oceanographic data (temperature, salinity, dissolved oxygen, currents);

(e) Comparisons with biological data (phytoplankton and zooplankton);

(f) Comparisons with non-acoustic surveys (eggs and larvae);

(g) Comparisons with data regarding other species: the prey species and the predator species of the population being studied and therefore also with the feed chain;

(h) Comparison with data coming from the markets (catches) and the statistical processing of same (population dynamics);

(i) Research on the geometric and structural characteristics of schools and their behaviour within environmental parameters;

(j) Acoustic research.

At present we are not yet in a position to achieve all the objectives potentially offered by this research, nor are we able to utilize in full the data that have been obtained in the Upper and Middle Adriatic, namely:

The estimates (absolute and relative) of the density of the resources, by species;

Their geographic distribution and variability in years;

The geometric and structural characteristics of the aggregations of pelagic fish by species.

This is due, in my opinion, to several factors, some economic (the research involved requires large investments) and some human (the approach to this research must be multi-disciplinary and therefore requires experts from several fields) while others are related to the difficulties to utilizing the results of research for practical purposes.

2. BASIC METHODOLOGY

The evaluation of pelagic resources using electroacoustic methods can be divided into two main themes:

The first (calibration of the system) is centred on the procedures for understanding the properties of the echoes coming from a sample of pelagic fish from the population being studied having known biophysical characteristics (species and size);

The second (acoustic survey) turns on resolving the inverse problem, namely the attempts to deduce from the analysis of the acoustic signals, compared with those obtained during calibration, information on the biophysical characteristics (species and size) and on the distribution and density (biomass) of the population being studied.

An acoustic survey consists of travelling over the area of sea we wish to explore (in our case the Upper and Middle Adriatic) in accordance with specific trajectories or tracks.

The choice of form (grid, zig-zag, etc.) and the length of the tracks is made with a view to having maximum coverage of the region under examination and minimum risk of sampling the same mass twice.

The exploration must also adequately represent (on the basis of information obtained from previous surveys or through other channels) the real distribution of the population under examination.

The data collected during an acoustic survey are:

(a) Data coming from electroacoustic instrumentation (Echo sounder, Sonar, Echointegrator)

The echo sounder explores the volume of sea from the keel of the ship to the bottom of the sea (along the bow), emitting 96 pings a minute.

The sonar explores the volume of sea at the side of the ship (along the beam) to a maximum distance of 1 500 m.

The echointegrator processes the echo signal so as to furnish per unit of distance (1 n mi) the average density of pelagic fish referred to the unit of depth (1 m).

(b) Data regarding the ship

These include two groups of quantities:

Quantities that serve to localize the ship and know its movement. These concern the direction of the ship with respect to the north (gyrocompass), its position (satellite system), speed and distance travelled (log);

Quantities influencing the relationship (signal/noise) of the electroacoustic instruments, as for example the pitch and roll, the number of revolutions of the engine, the slant of the propeller blades, etc.

(c) Atmospheric and biological oceanographic data

The oceanographic data collected for now are the surface temperature (thermoprobe placed on the ship's keel), the temperature profile and salinity (bathysonde) which are collected at specific stations along the survey route.

In any case it is believed that later on it would be useful to measure other oceanographic (dissolved oxygen, currents, water transparency) and biological quantities (phytoplankton and zooplankton nutritive salts).

The meteorological data are: wind direction and intensity, air pressure, humidity and temperature, solar radiation.

(d) Data on catches using sampling net

These data serve essentially for identifying the species and size by catch in a net three or four times a day.

They are used consequently to confirm the analysis of electronically received acoustic signals and to interpret the output of the echointegrator (echograms).

The data from catches with nets include:

Volume (in kg) and composition (by species) of the catch;

Distribution by size of the various species (histograms).

The data collected are processed at different times. A first processing is made on board the ship (preliminary processing), in general with the help of a minicomputer so as to be able to modify, gradually as necessary, depending on the results obtained, the basic plan of exploration of the region.

A second processing is made when the survey is over, in general with a more powerful calculator and using several statistical models of the resulting distribution.

For each model it is possible to calculate the probable error and consequently choose the model which best satisfies the experimental data.

After the data are processed, one has information that is useful not only for knowing the distribution and density of the species being studied (biomass maps) but also for making the subsequent survey more complete and reliable than the previous one.

Nevertheless, it should be noted that the absolute datum of biomass from a single survey should be considered with great caution for the following reasons:

One single survey does not give definitive results on a specific stock, especially if, as in the case of the Adriatic, we are not able to explore the entire area of distribution of the population.

In fact migrations to and from Yugoslavian territorial waters can cause considerable fluctuations in the datum of biomass for the area explored.

A good idea can be obtained of the annual biomass from three surveys (for example one made during the low density period, a second during the medium density period and a third during the peak density of the population being studied).

The results of the survey are subject to errors, some potential others effective (both statistical as well as technological and biological) requiring a careful and detailed examination.

## 3. SURVEYS COMPLETED AND RESULTS OBTAINED

### 3.1 Sardine Stocks

The research began in 1975 with a seminar (15 January to 15 February) followed by a survey (21 July to 4 August) on a small scale (from Porto Potenza Picena to Fano) for the purpose of making a test in the area being studied, checking out the programme and instruments and training the men. The electronic instrumentation was calibrated on the sardine (Sardina pilchardus (Walb.)) and the area explored was 500 n $mi^2$.

The results showed that the average density of this species in the zone taken as a sample for the middle Adriatic during that period was about 50 t/n $mi^2$, with maximums around the bathymetric measurement of 50 m between Porto Potenza Picena and Ancona (90 t/n $mi^2$) and off Fano (60 t/n $mi^2$), while the biomass was extremely low beyond the bathymetric point of 50 m and in a narrow zone near the coast (below bathymetrics of 20 m).

The 1976 survey(11-22 June), which covered an area of about 3 850 n $mi^2$, can be considered a pilot survey for the upper and middle Adriatic (from Trieste to San Benedetto).

The primary objective in fact was to have some indication of the real geographic distribution of the population being studied (Sardina pilchardus (Walb.)) so as subsequently to be able to project the runs for exploring the area better.

This survey confirmed among others that the average density of sardines in the zone between Fano and Porto Potenza Picena, explored in 1975, was about 50 t/n $mi^2$.

The type of distribution found suggested furthermore that the upper and middle Adriatic can be subdivided into a certain number of imaginary "roads" extending longitudinally and generally set off by bathymetrics of 20, 50, 75, 100 m.

The most interesting strip of sea is between 20 and 50 m, as shown in Figure 1.

It includes an area of medium density, equal to 55% of the entire area explored and containing about 33% of the entire biomass, two small range areas, one off the Po delta and the other off Istria, which altogether constitute only 9% of the area explored but include 60% of the entire biomass, and a low density area off the lagoon of Venice (ranging over 11% of the total area with 2% of the biomass).

The remaining 5% of the biomass is distributed beyond bathymetrics of 50 m and below 20 m which represent 25% of the area explored. The total biomass in the entire area of exploration was calculated at about $(180 \times 10^3) \pm 30\%$ t (out of 3 850 n $mi^2$).

Based on the information obtained from the 1976 survey, the plan for sampling the upper and middle Adriatic was made in 1977 (19 June - 10 July) by following grid runs oriented generally perpendicularly in relation to the bathymetrics.

The area explored in 1977 was about 8 200 n $mi^2$, i.e., the entire sea zone included between the Italian coast and the territorial waters of Yugoslavia from Trieste to San Benedetto.

The total biomass was calculated at about $(450 \times 10^3) \pm 15\%$ t (450 000 t/8 200 n $mi^2$ = 54 t/n $mi^2$).

The considerable improvement in the gap of confidence of this estimate confirms the validity of the hypothesis made as to the type of distribution of the population under study.

Also in 1977 the most interesting strip of sea was enclosed within bathymetrics of 20 and 50 m, as shown in Figure 2.

It includes a medium density area (equal to 34% of the entire area explored and containing 42% of the biomass), three high density areas in the upper Adriatic (one off the Po delta, another off Istria and the third in the Gulf of Trieste) which altogether constitute 7% of the area explored and include 33% of the entire biomass, and a high density area in the middle Adriatic (off Fano) with a range equal to 1.5% of the area explored and 6% of the biomass.

The remaining 19% of the biomass is spread mostly in vast areas falling beyond the bathymetrics of 50 m (55% of the area explored) and in the narrow strip below 20 m (2.5% of the area explored).

In general it can be said that the distribution of sardine stocks varied little between 1976 and 1977; nevertheless there was a remarkable increase in the total biomass.

In fact, comparing the areas explored both in 1976 and in 1977 (Figure 3) one can see that the biomass went from $180 \times 10^3$ t to $320 \times 10^3$ t (an increase of 78%).

This in our opinion is due above all to the effect of migrations to or from the Yugoslav area.

This result could be checked if the volume of the catches, their composition (by sizes) and the fishing effort during 1975-76 and 1976-77 were known.

Unfortunately we could only get data on partial catches for this period of time showing that catches of sardines between June 1975 and June 1976 amounted to $12 \times 10^3$ t, whereas between June 1976 and June 1977 they amounted to $21 \times 10^3$ t.

Note that the increase in catches in the two periods (75%) is of the same order as the increases in biomass verified by acoustic means.

In the 1977 survey other important characteristics of sardine stocks were studied (type of aggregation in relation to light, the depth of the sea-bed and the geographic zone), the most important being, in our opinion and also from the practical point of view, the configuration of the school (geometric and structural).

According to the results obtained, the horizontal range of the schools of sardines fell into 4 predominant classes:

Class 5 - 10 m (31% of the schools examined)

Class 10 - 15 m (13% of the schools examined)

Class 15 - 20 m (12% of the schools examined)

Class 20 - 30 m (18% of the schools examined)

As for the vertical range, there were two predominant classes:

Class 3 - 5 m (25% of the schools examined)
Class 5 - 8 m (27% of the schools examined)

Very rarely did the vertical range of a school of sardines exceed 20 m.

Finally the predominating class of volumes fell between 100 and 500 $m^3$.

The average depth of the centre of gravity of a school of sardines is usually above 20 m (40% of the schools examined), while the average density is around 7 individuals/$m^3$ by day and drops to 2 to 3 individuals per $m^3$ at night.

In 1978 three surveys were attempted (June, September, October) on sardine stocks; unfortunately various engine troubles and breakdowns of the ship's alternators prevented completion.

In 1979 the ship was worked on to make it more stable and consequently was not available for acoustic surveys.

During this interval the system for acquiring data was considerably improved as will be described later.

3.2 Anchovy Stocks

In 1978 (15-27 February) the first acoustic survey on anchovy stocks (Engraulis encrasicolus) was carried out in the middle Adriatic from Porto Corsini to San Benedetto.

The area explored was about 2 300 n $mi^2$ and the biomass total was estimated at $350 \times 10^3$ t.

If one compares this result with the results obtained for sardine stocks one notes the following:

1975 survey (sardine stocks):
Average density in the area explored: 50 t/n $mi^2$

1976 survey (sardine stocks):
Average density in the area explored: $\frac{180 \times 10^3 \text{ t}}{3\,850 \text{ n mi}^2} = 46$ t/n $mi^2$

1977 survey (sardine stocks):
Average density in the area explored: $\frac{450 \times 10^3 \text{ t}}{8\,200 \text{ n mi}^2} = 55$ t/n $mi^2$

1978 survey (anchovy stocks):
Average density in the area explored: $\frac{350 \times 10^3 \text{ t}}{2\,300 \text{ n mi}^2} = 150$ t/n $mi^2$.

In general it can be said therefore that the average density of anchovy stock is about 3 times higher than sardine stock.

Approximately the same result is obtained if one compares the biomass of sardines and anchovies in the area explored both in 1977 and in 1978:

1977 survey (sardine stocks):
Middle Adriatic (2 300 n $mi^2$), total biomass $130 \times 10^3$ t

1978 survey (anchovy stocks):
Middle Adriatic (2 300 n $mi^2$), total biomass $350 \times 10^3$ t.

The difference between sardine and anchovy stocks is not limited to the difference between the densities of the biomass.

In effect also the type of spatial distribution, the configuration (geometric and structural) of the schools and their behaviour in relation to light are profoundly different.

The population of anchovies is not distributed longitudinally as the sardines are within strips set off by bathymetrics, but in islands of extremely high density, surrounded by a ring of medium high density and submerged in an area of very low density as shown in Figure 4.

The type of distribution makes the anchovy stock much more vulnerable to fishing equipment than sardine stock.

Vice versa distribution in islands provides better protection against predators.

In the 1978 survey three islands of very high density were found, one off San Benedetto, the second off Ancona (beyond bathymetrics of 50 m) and the third ranging from Ancona to Fano, totalling about 12% of the entire area explored, and the biomass contained in these islands amounted to 73% of the total biomass.

These islands are surrounded by rings of high-average density.

Their surface totals 27% of the area explored and the biomass they accommodate is 16% of the total biomass.

Off San Benedetto (beyond bathymetrics of 50 m) and in the sea area between 25 and 50 m and extending from Pesaro to Porto Corsini there are another two islands of average density whose surface totals 11% of the area explored with 9% of the total biomass. These concentrations of anchovy stock are submerged in a vast area (equal to 46% of the entire region explored) which accommodates only 2% of the total biomass.

If one then proceeds to compare the configuration of the schools of sardine and anchovy stock, one can say that the latter have dimensions which are greater both horizontally (the predominant classes are those included between 15 and 100 m) as well as vertically, even though less marked (the predominant classes are those included between 5 and 30 m).

Consequently, the volumes of schools of anchovies are distributed in classes higher than those of sardines (the most important class is the one with volumes between 5 000 and 10 000 $m^3$ which contain about 20% of the schools sampled).

Also the internal structure of the schools of sardines and anchovies is different, such as the mechanism of the breaking-up of the school as solar radiation decreases (night).

For example, by day the schools of anchovies have more individuals per cubic metre than the sardines (8 individual/$m^3$) but at night are more rarified (1-2 individuals/$m^3$).

## 4. PROSPECTS AND THE OPENING OF NEW HORIZONS

The results obtained, briefly summarized in sections 3.1 and 3.2, open up a series of problems of great interest from both a scientific and practical point of view.

A first series of problems concerns the "microscopic" parameters characterizing the population under examination, in other words the single individuals, or the aggregation of individuals (schools) while a second series of questions refers to parameters related to the entire population inhabiting the region explored ("microscopic" parameters) in other words, its distribution, its biomass, and the movements and fluctuations of these two quantities over the years.

Bioacoustics is a science which tries to extract biophysical information (species/size/weight) on unknown marine organisms from acoustic signals. Until today there had been no attempt to determine the size by acoustics, furthermore the determination of the species was subject to uncertainty, particularly in certain areas of the sea inhabited by several closely related species.

The first problem we have raised therefore is the following:

Is it possible to decrease or eliminate the uncertainties in our determination of the species by making a careful geometric and structural examination of the schools?

On the basis of the results obtained, it is possible to hypothesize that each species of clupeids tends, in a certain environment and in a certain life cycle, to form a school with typical characteristics which permit the species to have a highly adaptive behaviour both from the social as well as defensive/offensive point of view.

The second problem is more strictly related to the rapid development of digital techniques which permit singling out one individual from a school and can be formulated in the following terms:

Is it possible once an individual of a species under examination has been singled out to determine its size? The answer to this question requires not only having the instruments for making a careful examination of the T.S. of a single fish, but also for refining the method of measurement with electroacoustic instrumentation which is to be done not only in relation to the species but also to the size.

To answer these two questions, in 1978 the study of a system based on a minicalculator was begun and continued in 1979 and should be able to:

Analyse the aggregations of pelagic fish by collecting first a series of significant images of schools and then by classifying them according to the species on the basis of the information memorized and Bayes' rule (image classification);

Single out the individual fish from the school and determine its size on the basis of a measurement of the Target Strength and a comparison with a curve of calibration found previously.

This project, presented to the Charles Stark Draper Laboratory (Boston, Massachussets) during a USA-USSR seminar on electroacoustic systems applied to fishing (25-29 June 1979) was found to be of considerable interest.

It is in effect evident that if one succeeds in determining by acoustic means the size of the pelagic species being studied, it is possible, using acoustic data only, to answer a question of great practical importance such as:

How much of the estimated total biomass can be taken?

Naturally, even if one succeeds in determining sizes and species by acoustic means, the use of the net will be continued later for sampling marine organisms both for checking the acoustic technique and for obtaining a variety of information on the physiological state of the fish (stomach contents, maturity, sex, age, etc.) which can only be obtained from a direct sampling.

In any case we note that sampling with a net too presents a series of problems which cannot be easily solved (which net is optimum from the point of view of selection according to size and species?).

As for the microscopic quantities (biomass, its distribution in the region, its movement in time), we can summarize the results of an acoustic survey as follows:

The explored region can be subdivided into a certain number of dominions in which the density is almost constant and the behaviour of the pelagic fish in relation to light is statistically determined.

Vice versa in distinct dominions there are more or less marked differences in density and behaviour.

The problem this result poses is the following:

What has caused this type of distribution and how can it be described in a mathematical form?

To answer this question we must know the physical, chemical and biological, as well as physiological stresses in the species under examination, and also those stresses due to the presence of other species competing with the species under examination for the same food.

If one then looks at the results (density maps) of the two (or more) surveys that follow, one sees a movement in areas of higher density (nuclei of the region) in accordance with certain trajectories.

The problem posed in this case is: Can these trajectories be predicted in some way and do they occur in accordance with regular cycles?

It is evident that to solve these problems in future, oceanographic and biological measurements must become increasingly important and that bioacoustic engineers must have at their disposal the help of mathematicians, oceanographers and biologists.

The importance - also practical - of these solutions is truly significant (one needs but consider that consequently it would be possible to regulate not only the fishing effort, but also its distribution in the region) and therefore, in my opinion, adequate investments would be justified in order to obtain these solutions.

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Annex F

# ETAT DES STOCKS D'ANCHOIS ET DE SARDINE EN ADRIATIQUE

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Il y a presque un siècle que des chercheurs travaillent sur la biologie et la pêche des poissons pélagiques de la mer Adriatique.

La distribution des stocks, les fluctuations des captures, la biologie générale, les déplacements, les relations avec le milieu, les zones et les périodes de reproduction et les phases planctoniques ont été considérés.

Toutes ces données, qui ont contribué à l'amélioration des connaissances, malheureusement ont été récueillies d'une façon souvent fragmentaire et indépendante d'un laboratoire à l'autre.

La pêche des poissons pélagiques est économiquement très importante pour les pays côtiers et les captures annuelles sont estimées à plus de 100 000 t.

Il y a actuellement une tendence à augmenter la pêche des poissons pélagiques, soit à cause de problèmes de la pêche démersale, soit pour une plus grande demande de protéines animales.

Dans ce contexte il y a cinq années que les laboratoires de Split, Fano et Trieste ont établi un programme en collaboration pour l'évaluation des stocks d'anchois puis de sardine. Ces programmes ont été réalisés à partir de 1976.

La méthode choisie pour ces recherches a été la méthode des oeufs à cause des nombreuses connaissances préalables et des compétences disponibles. D'autre part cette méthode est la seule qui permette une évaluation strictement spécifique, en l'absence de séries valables de données statistiques de capture et d'effort. La méthode utilisée consiste à évaluer la quantité totale d'oeufs pondus dans toute la saison de ponte dans l'aire de reproduction. Cette quantité reliée à la fécondité relative et à la répartition des sexes permet d'estimer la biomasse totale des reproducteurs. Si l'on veut connaître la biomasse totale de la population il faut disposer du rapport entre les reproducteurs et les immatures.

La zone considerée dans les recherches a toujours été la même, c'est-à-dire toute l'Adriatique au nord de la ligne promontoire du Gargano-Kotor (surface approximative de 101 700 $km^2$). Cette limite a été déterminée pour les différences morphologiques et hydrologiques existant dans le sud Adriatique qui représente probablement la limite des zones plus intensives de reproduction de deux espèces étudiées.

Pour déterminer la quantité totale des oeufs pondus nous avons fait chaque année des croisières en couvrant toute la zone avec des stations de prélèvement quantitatif d'ichthyoplancton avec un filet "Bongo - 20" en pêches doubles obliques jusqu'à la profondeur maximale de 50 m.

Cela nous a permis de déterminer les aires de ponte et leurs importances relatives. Pour suivre les intensités de la ponte et ses variations au cours de toute la saison nous avons realisé des séries de prélèvements périodiques en stations fixes en trois zones différentes (golfe de Trieste, Fano et Split). Ensuite nous avons relié les variations de l'intensité de la ponte avec la quantité d'oeufs pondus dans toute la zone étudiée en déterminant la quantité totale des oeufs pondus.

Parallèlement on a échantillonné les populations adultes en déterminant le poids moyen des adultes, la fécondité moyenne en relation au poids et le rapport des sexes.

Les indications préliminaires que nous avons obtenues pour l'anchois montrent que même sans considérer la mortalité des oeufs, la biomasse des reproducteurs est très élevée. En effet les estimations sont les suivantes:

| | | | |
|---|---|---|---|
| 1976 | 927 000 t | 1978 | 2 267 000 t |
| 1977 | 1 398 000 t | 1979 | 3 193 000 t |

Ces valeurs ont été obtenues en utilisant les mêmes paramètres qu'en 1976 (Piccinetti, Regner et Specchi, 1979[1]) et sont comparables entre elles.

Toutes les estimations ont été réalisées sans aucune correction pour la mortalité et lorsqu'on fera les corrections, les valeurs des estimations changeront ou augmenteront.

Il est évident d'après les résultats que la biomasse des reproducteurs d'anchois est en train d'augmenter et que le stock ne semble pas être influencé négativement par l'activité de pêche présente.

Les indications obtenues pour la sardine sont limitées aux deux dernières années, et il faut préciser qu'il est, pour le moment, très difficile d'établir une courbe représentative des variations saisonnières de l'intensité de la ponte qui sont différentes d'une zone à l'autre à cause des déplacements très rapides des bancs de sardines.

Pour cela les estimations obtenues sont préliminaires et demandent une étude ultérieure.

Les données pour les saisons de reproduction sont les suivantes:

| | |
|---|---|
| 1978-79 | 402 000 t |
| 1979-80 | 963 000 t |

Ces données considèrent une correction pour la mortalité des oeufs. La biomasse des sardines semble augmenter mais elle est toujours considérablement plus faible que la biomasse d'anchois; en plus les sardines présentent une durée de vie supérieure à celle des anchois et cela se reflète sur la quantité maximale que on peut pêcher.

Nos estimations de stock de reproducteurs de l'anchois et de la sardine indiquent, même avec les limites déjà indiquées, que dans l'Adriatique il y a une quantité importante de poissons pélagiques, quantité qui pourrait soutenir une certaine augmentation de la pêche.

Avec ces recherches nous avons aussi déterminé la distribution théorique des stocks des reproducteurs au cours de la saison de ponte pendant différentes années (voir figures jointes); ces informations sont d'un certain intérêt pour connaître les concentrations des poissons et ses variations en liaison avec les facteurs hydrologiques et trophiques que nous avons étudiés ensemble.

Notre programme dans l'avenir est de continuer nos campagnes pour obtenir les renseignements immédiats sur les variations des stocks (notre évaluation actuelle du stock de sardine se réfère à la saison de ponte qui vient de se terminer) et en même temps pousser l'élaboration de nos données pour quantifier mieux les sources de variation existantes et aboutir à une dynamique complète des populations d'une façon indépendante de la pêche.

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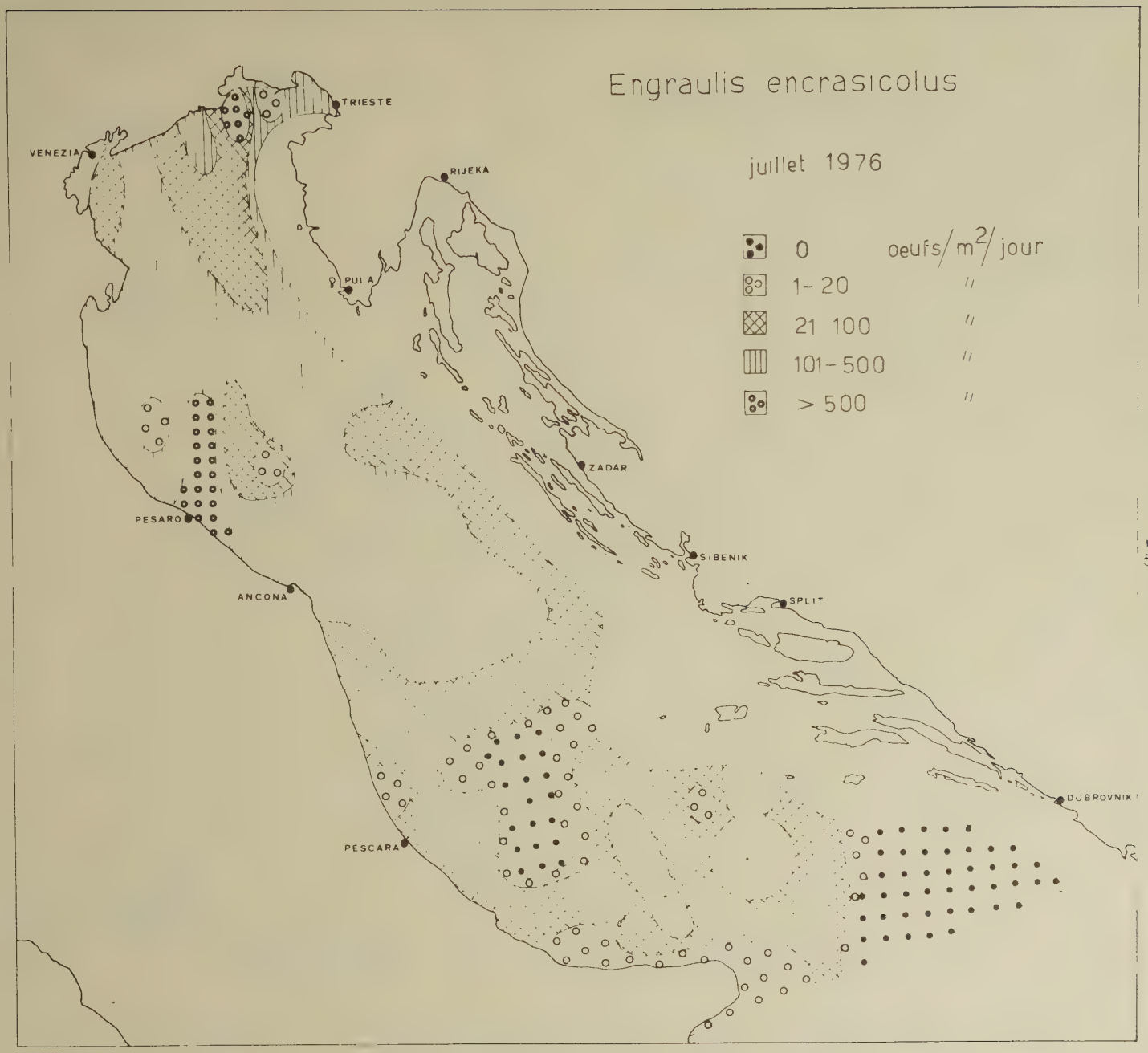
1/ C. Piccinetti, S. Regner et M. Specchi, Estimation du stock d'anchois (Engraulis encrasicolus L.) de la haute et moyenne Adriatique. Invest.Pesq., Barc., 43(1):69-81 1979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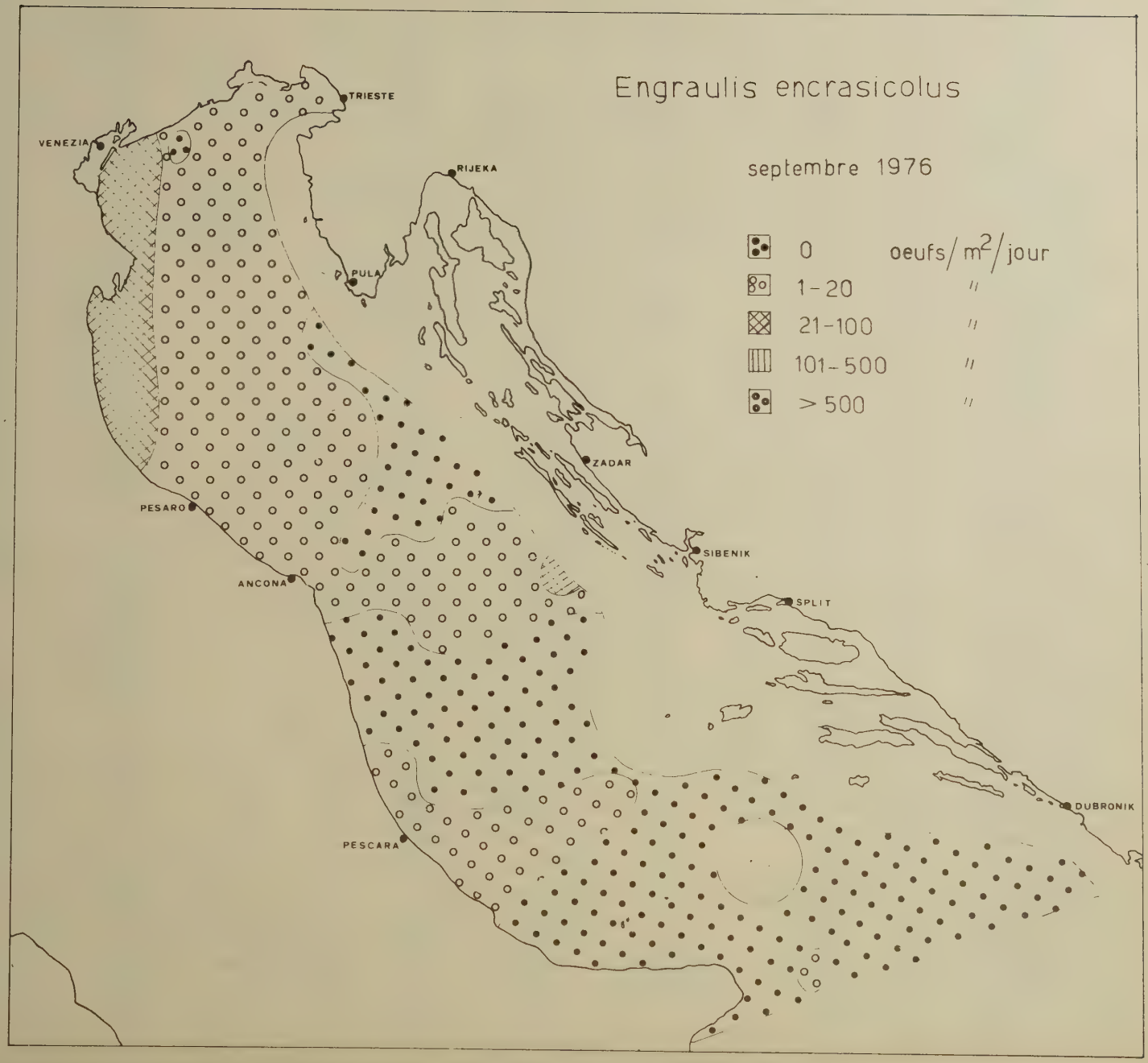
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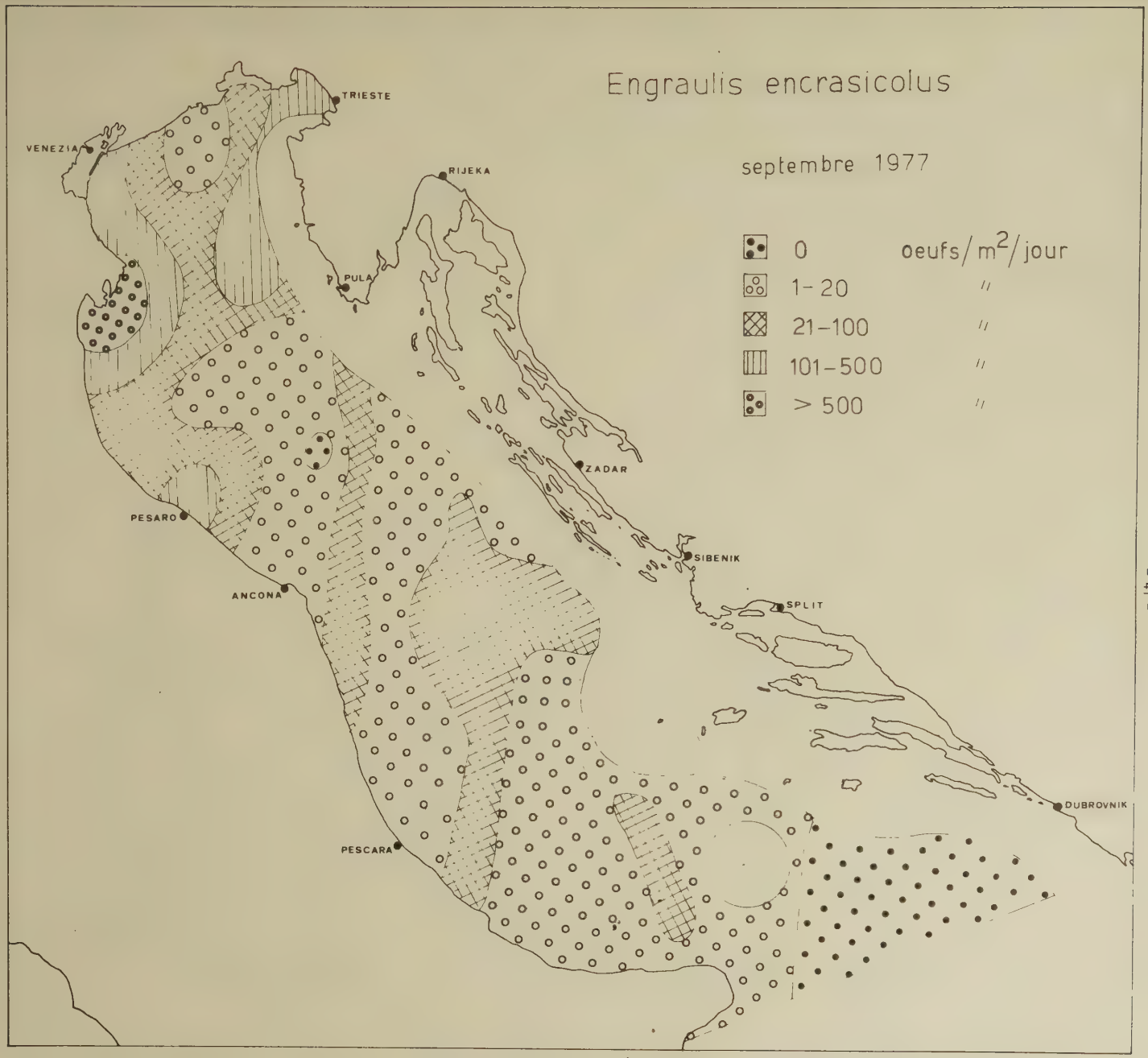
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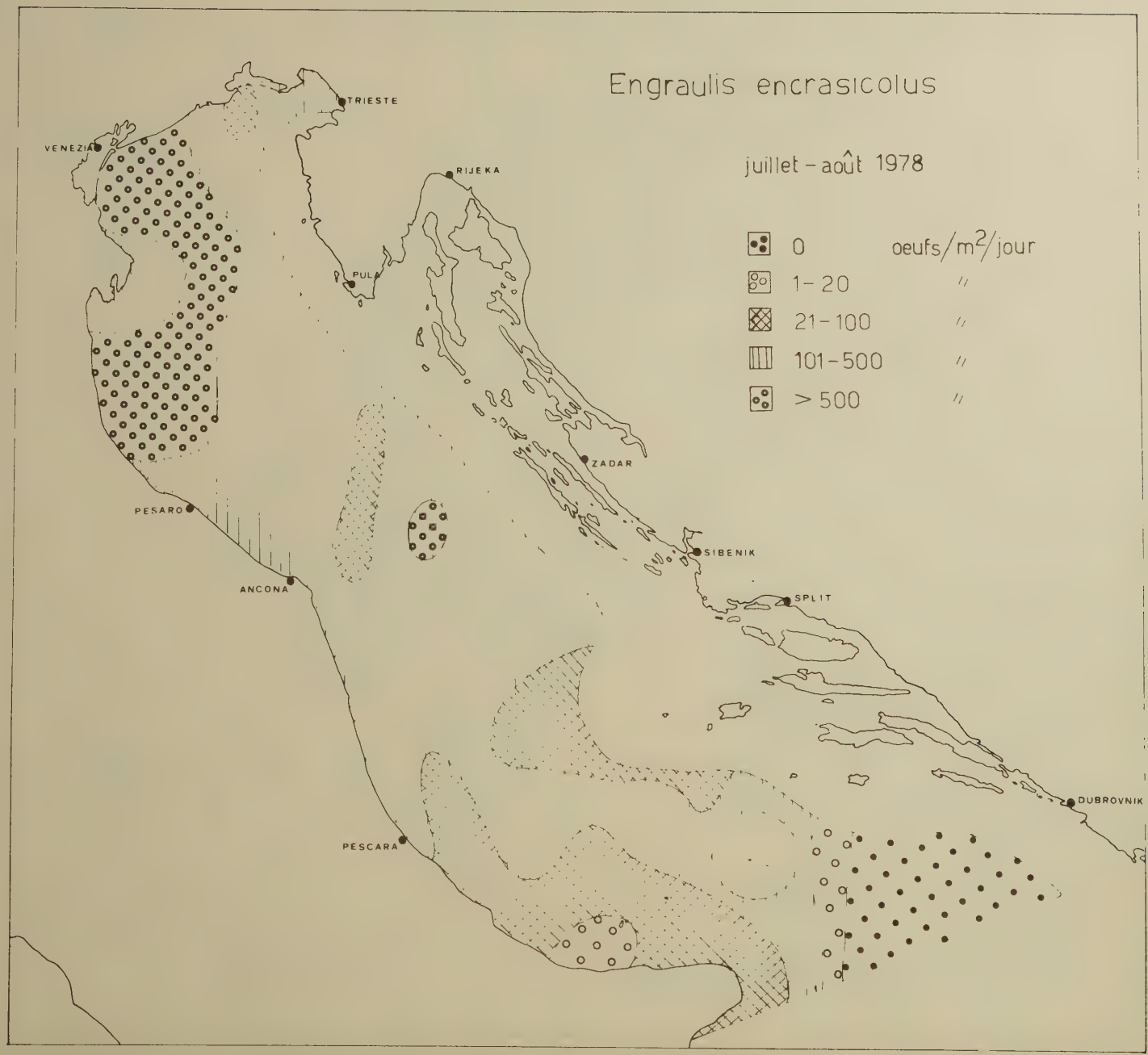
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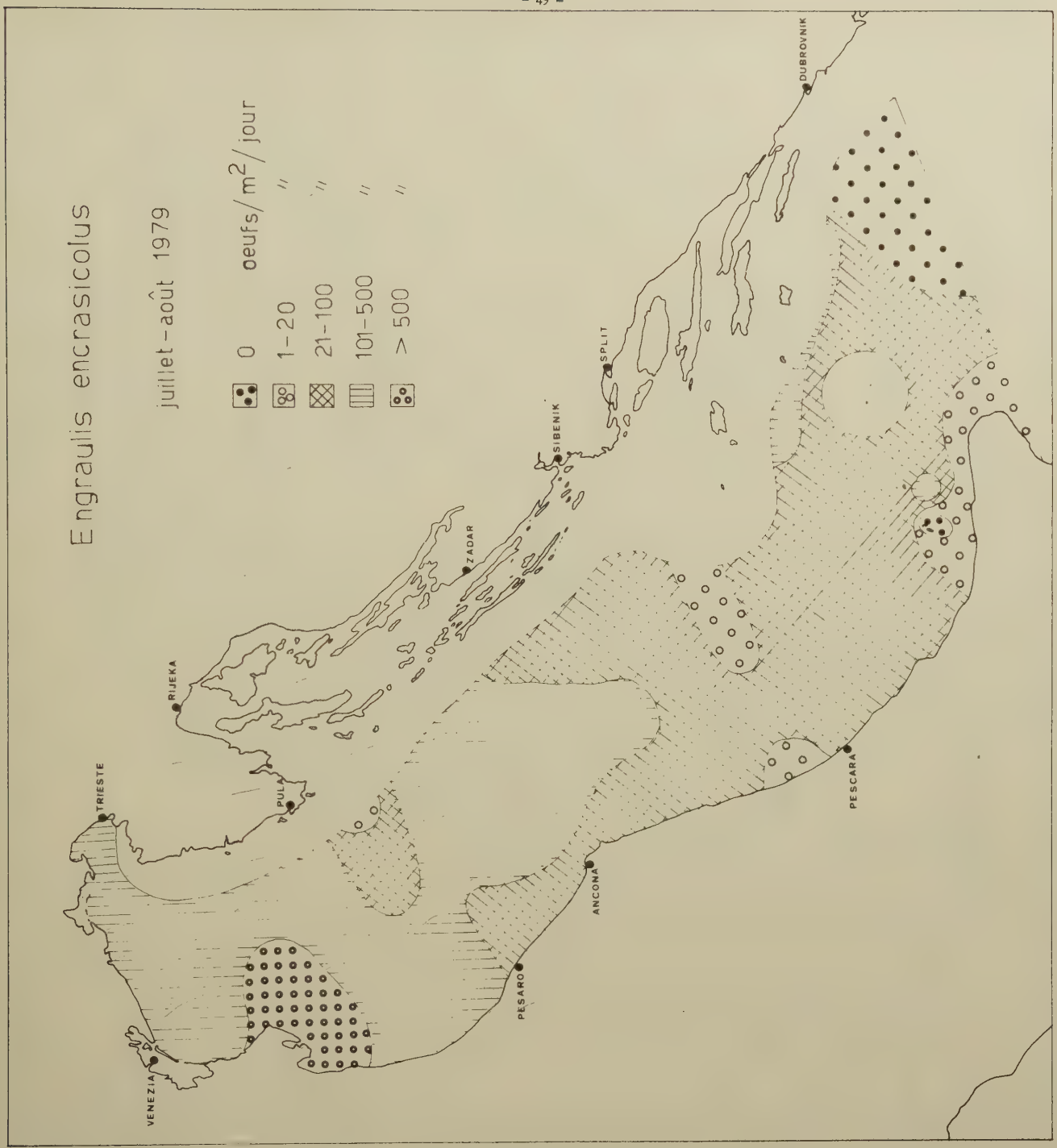
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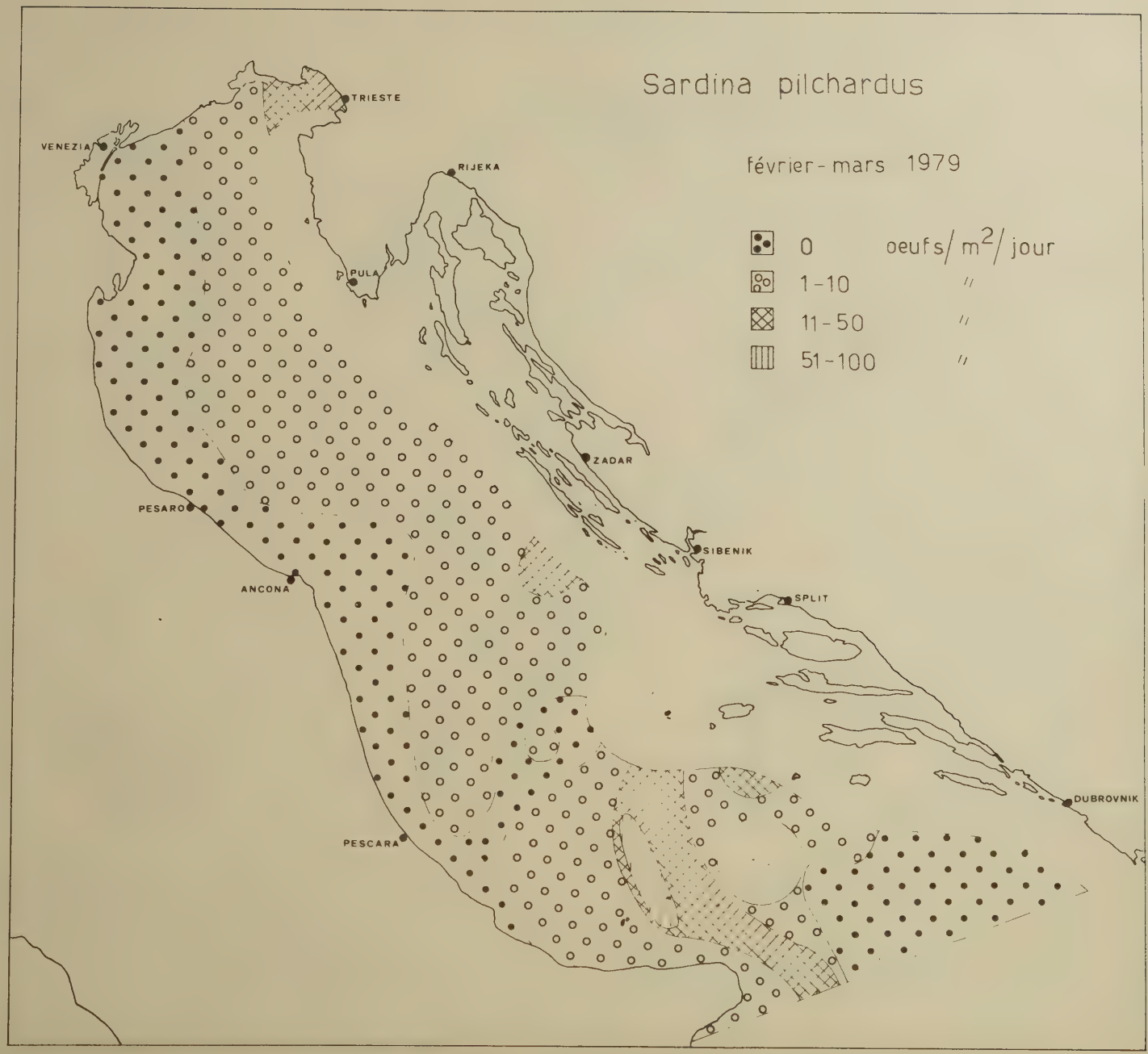
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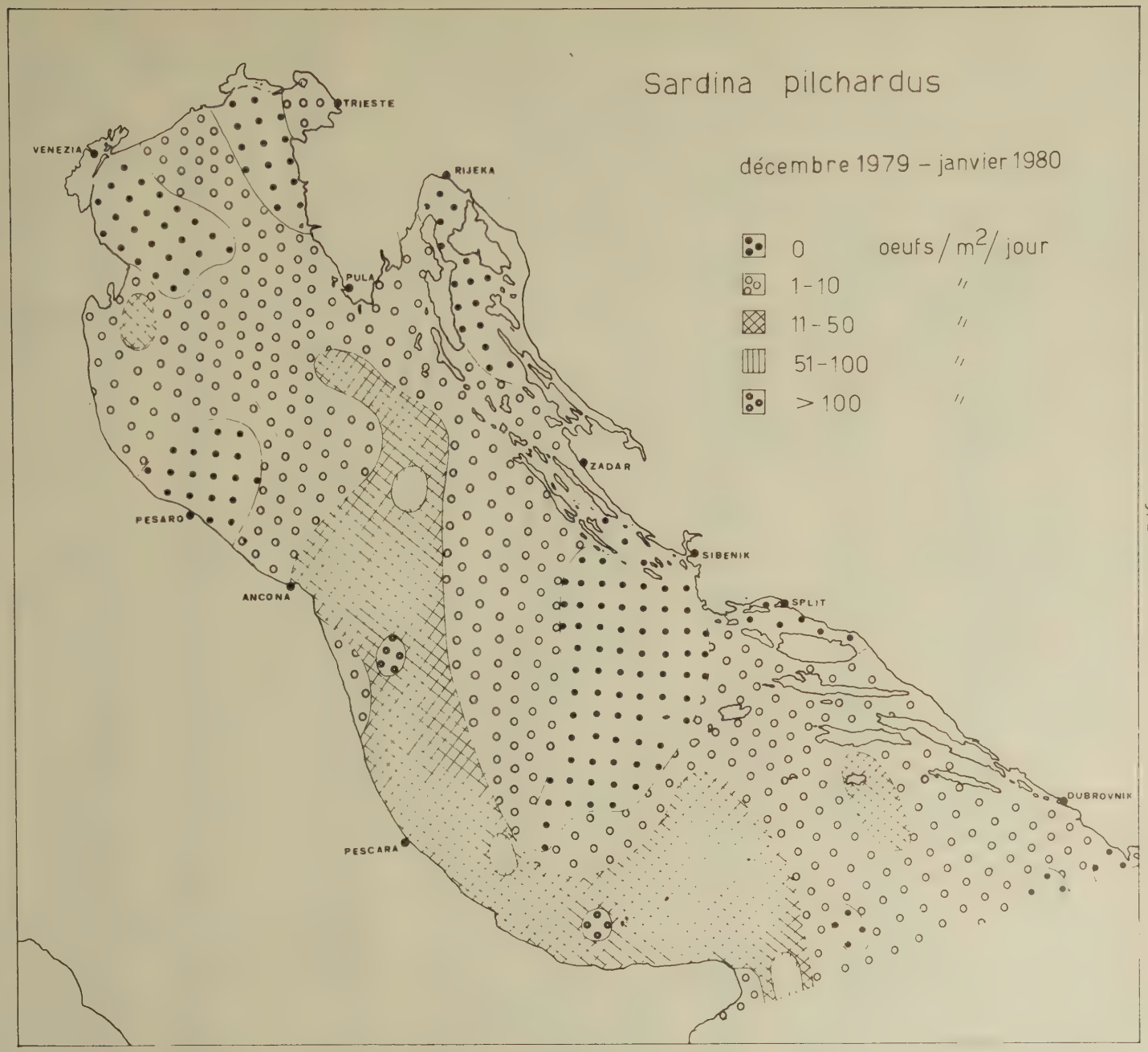
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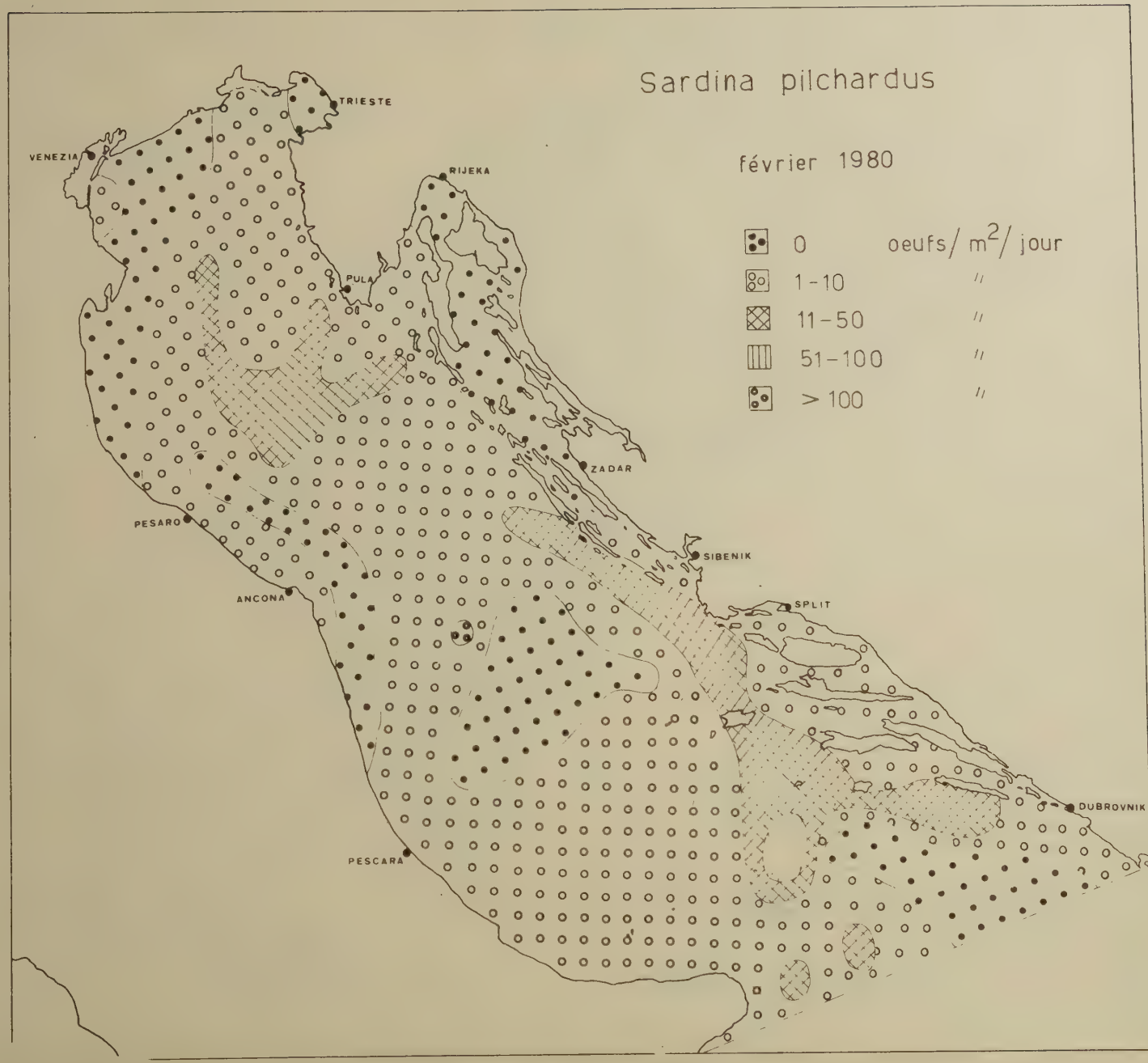
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Annex G

# FISHERY RESOURCES AND YUGOSLAV FISHERIES IN THE COASTAL AREA OF THE ADRIATIC SEA

by

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## I. INTRODUCTION

The exploitation of coastal fishery resources of the Yugoslav Adriatic part is now more a sport and recreational activity, or an additional activity than it is a commercial fishery.

Considerable changes in the coastal fisheries of Yugoslavia have taken place in the last thirty years. Till the second world war there was a rather large number of small fishing enterprises (fishery cooperatives) which mainly exploited the coastal area. Soon after, their number was gradually reduced. Thus, not more than ten of them have been left. This has led to the reduction in commercial exploitation of the coastal sea. At the same time, fishing on a private basis has increased either by individual professional fishermen or fishing groups or by fishermen for whom fishing has been an additional activity (occasional fishermen). Sport fishing has also developed. Notwithstanding these phenomena in the coastal fisheries of Yugoslavia, the power of coastal fishing gear has not been reduced (only the number of some kinds of fishing gear has been reduced or some have disappeared). On the contrary, it has continually increased, even to a considerable extent. Therefore, the exploitation of the coastal fishery resources has been intensified.

The researches on the state of fishery resources along the eastern coast of the Adriatic have been carried out for the last thirty years, but they have been more intensive for the last twenty. The results of the studies carried out, particularly for the last ten years, may be summarized as follows:

## II. DESCRIPTION OF THE AREA

In the Yugoslav coastal fisheries the depths down to about 80 m are mainly exploited. This includes the whole area of infralittoral step and the upper part of the circalittoral step.

The width of the coastal fisheries area varies to a considerable extent from only some 10 m to several kilometers offshore. The width depends mainly on the bottom configuration. However, its width is on an average about 300 m. The total area of this zone, together with the banks, is about 2 100 $km^2$. This is approximately 3.2% of the total area of the Yugoslavian Adriatic (Grubišić, 1968).

Physiographic, oceanographical and biological properties of the coastal area of the Yugoslavian Adriatic show great diversity. This results in plants and animal species developing in great abundance, giving a variety of opportunities for exploitation. As far as the productivity is concerned, this zone is one of the most productive in the Adriatic. This is due to the large quantities of nutrients, the small depths and transparency, the fresh water inflows and vicinity of the land (Buljan, 1964).

Primary production of the wider coastal area, according to Pucher-Petković and Zore-Armanda (1973), is estimated to be 60-150 g $C/m^2$/year. Annual fish production on the basis of primary production, taking into account three trophic levels and ecological efficiency of 15% respectively, would amount in this area to 60 000 t/year (?).

## III. METHODOLOGY AND RESULTS

Composition and density of coastal fish populations in the Yugoslav part of the Adriatic have been mainly studied using the trammel nets (Morović, 1965, 1970, 1971, 1979; Jardas, 1979, 1980) and less by other coastal fishing gear. Investigations on the state of the coastal fishery resources by the use of trammel nets have been continually carried out for the last twenty years. Trammel nets are one of the most numerous and most efficient coastal fishing gear, the number of which has increased nearly six times within the last twenty years (data of the Bureau of Statistics of Croatia). Trammel nets are of the same importance for the coastal fisheries as the otter trawl nets are for the deeper sea fisheries and, therefore, the data thus obtained are rather reliable.

A total of 40 families and 99 species of fish, 3 families and 4 species of cephalopods, and 6 families and 7 species of bigger crabs were recorded from the trammel nets catches realized along the Yugoslavian Adriatic coast between 1971 and 1979. This, however, is not, in fact, their total number in this coastal zone. Larger number of fish families are dominant (Labridae, Scorpaenidae, Triglidae, Sparidae, Mullidae, Soleidae, Cenracanthidae and some others) together with 25 species in terms of qualitative composition and quantities. The proportions of these families in the total fish catch is mainly between 41 and 80% in weight (Jardas, 1979). As to the qualitative composition, i.e., proportions of presence of individual fish families and species, the catches show, to a certain extent, a local character. Sparidae, Scorpaenidae, and Labridae families are predominant in number and distribution. The same is applicable to fish species as Scorpaena porsus, Symphodus(Crenilabrus)tinca and Diplodus annularis.

The dominant cephalopod species is Sepia officinalis, particularly in the spring months. Dominant crabs species are Scyllarus, Squilla and Maja. The species of the greatest interest for fisheries, Palinurus elephas and Homarus gammarus have been seriously depleted. The same holds for Maja squinado which is mainly caught in the northern Adriatic.

Total catch by trammel nets along the Yugoslavian Adriatic coast during the ten years of investigations (1971-1979) (Jardas, 1979) did not exceed 0.5 kg per net in most of the catches (46.8% of the analysed catches) 37.4% of the catches gave better results, i.e., from 0.5 to 1 kg, 15.1% gave a catch between 1 and 2 kg. Catches over 2 kg per net were recorded from only 0.7% of the sets. In general, better catches were realized from the more offshore sites (Morović, 1970, 1971; Jardas, 1979). The mean catch of fish per trammel net also did not exceed 0.5 kg for 64.7% of catches. The mean catch for other species was considerably lower.

Best catches were obtained during the spring and early summer months. The poorest catches were realized in colder periods, probably because of the periodic migrations of the coastal fisheries species.

The total catch obtained by coastal fishing gear along the Yugoslavian Adriatic coast in 1978 was 4 700 t, which accounted for 12-13% of the total Yugoslav marine catch (Table 1). This proportion exceeds the proportion of catch by otter trawl nets, which has recently been not more than 5-8%. Catches obtained by both these fishing methods are far below the catch of small pelagic fish (Clupeidae, Engraulidae, Scombridae), the proportion of which in the total catch amounts to even 80% (Table 2). Maximum coastal fishery catch of 5 824 t was achieved in 1971.

Total catch of fish, crabs, cephalopods and shellfish in the coastal area has recently shown a tendency of stagnation or even decrease ($b = -133.5$). The variations in the catches of the most important coastal species for the period after 1970 are given in Table 3. Trends in the total catch of the nineteen most important fish species of the coastal fisheries

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1/ Net dimensions: length 36 m, height 1.6 m, and mesh size of the mean layer 28 mm. Catching area about 57 $m^2$

(according to Table 3) in the period from 1970 on, have shown rapid decrease ($\underline{b}$ = -162.3). Reduction in catches has been noted in crabs as well ($\underline{b}$ = -1.7). Other animals, however, (shellfish and cephalopods) have shown an upward trend (the regression coefficients for shellfish $\underline{b}$ = 6.5 and cephalopods $\underline{b}$ = 15.5, Figure 1 - after Table 3).

If the increase in the power of coastal fishing gear and in the number of fishermen is compared with the total catch realized since 1970, the following may be noticed: the number of coastal fishing gear has been in continuous and rapid increase, as well as the number of fishermen (occasional fishermen), whereas the catch has shown a tendency to decrease (Figure 2).

From 1958 to 1970, the same trend of increase in the number of fishing gear was recorded together with a reduction in the number of occasional fishermen, and, what was indicative, a tendency of increase in the total catch. From the relationship between the number of occasional fishermen and the total catch in these two periods, completely opposite tendencies may be observed, with the interim period 1968-1971 (Jardas, 1980). These trends were on one side due to the legal regulations and on the other to the state of coastal fishery resources.

An opposite tendency in the trends in number of fishermen and fishing gear, on the one side, and total catch, which has recently decreased, on the other(paragraph 6), the continuous reduction in catches by trammel nets which are the most popular and numerous coastal fishing gear, as to the quality and quantity, which is evident from the observed period 1962-1979 (Morović, 1971; Jardas, 1979) were recorded, together with the decrease in annual catch of the more important coastal fishery species (paragraph 5). All this is indicative of the state of overfishing of the coastal fishery resources of Yugoslavia. Since 1962, i.e., during the period where the more or less permanent control of coastal fishery resources was carried out, a continuous reduction in the length and weight of characteristic fish and other animal species has been recorded, as well as a decrease in their frequency of occurrence in catches, i.e., the decrease in their population density (Morović, 1971; Grubišić, 1974). The most reliable evidence of the general overfishing is the decrease of the catches in spite of the continuous and considerable increase of fishing effort (Figure 2).

This shows that so far the measures which regulated coastal fisheries have been inadequate and insufficient. Therefore efforts have recently been made to apply more appropriate legal regulations to the coastal fisheries with the aim of protection and improvement of the present state. Even though this area is little known and studied, there are some indications that biological poverty of the coastal sea is partly due to the growing tendency of marine pollution (Jardas, 1977, 1978) which is most strongly felt just in the coastal area.

Under the conditions of the seriously disturbed natural balance in the coastal area caused by human activities (overexploitation and pollution of wider and wider marine areas) the perspectives for the coastal fisheries are difficult to define. The foregoing information indicates that the catch in the coastal zone could not be increased to any considerable extent by the increase of fishing effort. On the contrary, after a time the catch would be even decreased and followed by the new adverse consequences. This must not be permitted. The only perspectives for these fisheries are protection and recovery of their biological basis, as well as the artificial rearing (mariculture) for which the areas along the Yugoslav coast offer extraordinary potentialities (Morović, 1974).

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Table 1

Proportion of coastal fisheries in total Yugoslav sea fisheries after 1970 (in tons)

| Year | Total catch | Coastal fisheries | | |
|---|---|---|---|---|
| | | Total | % | Index (1970 = 100) |
| 1970 | 26 738 | 5 548 | 20.7 | 100 |
| 1971 | 30 847 | 5 824 | 18.9 | 105 |
| 1972 | 30 721 | 5 108 | 16.6 | 92 |
| 1973 | 30 354 | 4 084 | 13.5 | 74 |
| 1974 | 30 217 | 4 449 | 14.7 | 80 |
| 1975 | 32 251 | 4 853 | 15.0 | 87 |
| 1976 | 34 855 | 4 790 | 13.7 | 86 |
| 1977 | 35 249 | 4 784 | 13.6 | 86 |
| 1978 | 37 466 | 4 702 | 12.6 | 85 |

Table 2

Catch per kind of fisheries and total catch in Yugoslav sea fisheries after 1970 (in tons)

| Period/Year | Total catch | Catch of pelagic fishes | Coastal fisheries | Trawl fisheries |
|---|---|---|---|---|
| 1970-1978 | 32 085 | 25 245 | 4 905 | 1 832 |
| 1977 | 35 249 | 27 628 (78.4%) | 4 784 (13.6%) | 2 837 (8.0%) |
| 1978 | 37 465 | 29 923 (79.9%) | 4 702 (12.6%) | 1 970 (5.3%) |

Table 3

Catch of the important fish, cephalopod, crab and shellfish species in the Yugoslav coastal fisheries after 1970 (in tons)

| Species | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|---|---|---|---|
| 1. FISHES: | | | | | | | | |
| *Dentex dentex* (L.) | 82 | 93 | 67 | 61 | 47 | 46 | 51 | 52 |
| Mugilidae | 327 | 364 | 230 | 275 | 252 | 203 | 260 | 243 |
| *Anguilla anguilla* (L.) | 97 | 81 | 38 | 56 | 49 | 35 | 53 | 43 |
| *Dicentrarchus labrax* (L.) | 66 | 66 | 55 | 54 | 54 | 46 | 42 | 39 |
| *Sparus aurata* L. | 79 | 89 | 70 | 86 | 74 | 69 | 69 | 62 |
| Centracanthidae | 787 | 868 | 775 | 589 | 644 | 547 | 521 | 525 |
| *Boops boops* (L.) | 1 137 | 1 053 | 820 | 572 | 600 | 592 | 546 | 509 |
| Atherinidae | 135 | 150 | 132 | 160 | 187 | 187 | 139 | 194 |
| *Sarpa salpa* (L.) | 155 | 127 | 115 | 107 | 140 | 170 | 168 | 138 |
| Scorpaenidae | 172 | 183 | 175 | 158 | 178 | 162 | 170 | 202 |
| 2. CEPHALOPODS: | | | | | | | | |
| *Loligo vulgaris* Lam. | 234 | 239 | 209 | 191 | 271 | 263 | 261 | 263 |
| *Sepia officinalis* (L.) | 153 | 157 | 186 | 171 | 206 | 233 | 207 | 208 |
| *Octopus vulgaris* (L.) | 103 | 136 | 132 | 98 | 98 | 85 | 107 | 133 |
| 3. CRABS: | | | | | | | | |
| *Homarus* and *Gammarus* spp. | 32 | 43 | 24 | 16 | 14 | 16 | 20 | 20 |
| *Maja squinado* (Herbst) | 74 | 99 | 121 | 88 | 85 | 77 | 85 | 115 |
| 4. SHELLFISH: | | | | | | | | |
| *Ostrea edulis* (L.) | 72 | 73 | 85 | 65 | 122 | 202 | 84 | 78 |
| *Mytilus galloprovincialis* (Lam.) | 173 | 244 | 430 | 275 | 287 | 320 | 266 | 297 |
| Other shellfishes | 110 | 109 | 104 | 86 | 58 | 61 | 69 | 73 |

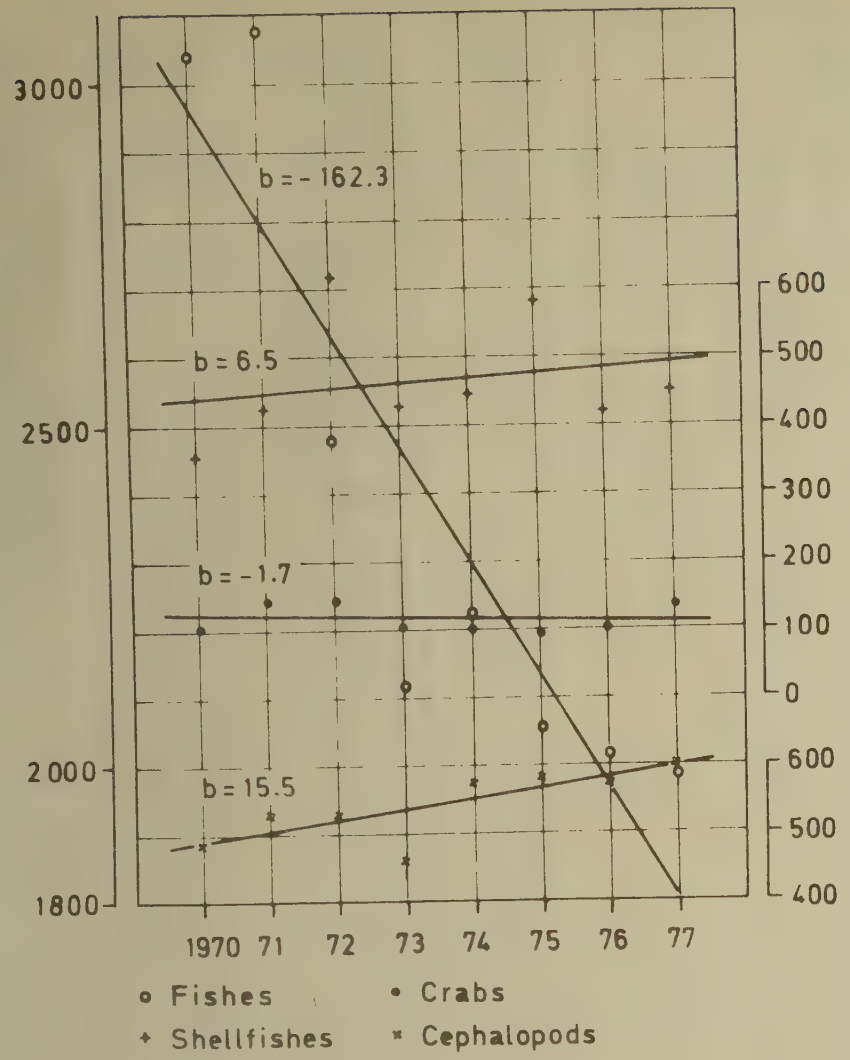



Fig.1: Trends of total catch of the most important fish, crab, cephalopod and shellfish species in the coastal fisheries in the period after 1970 (in tons)

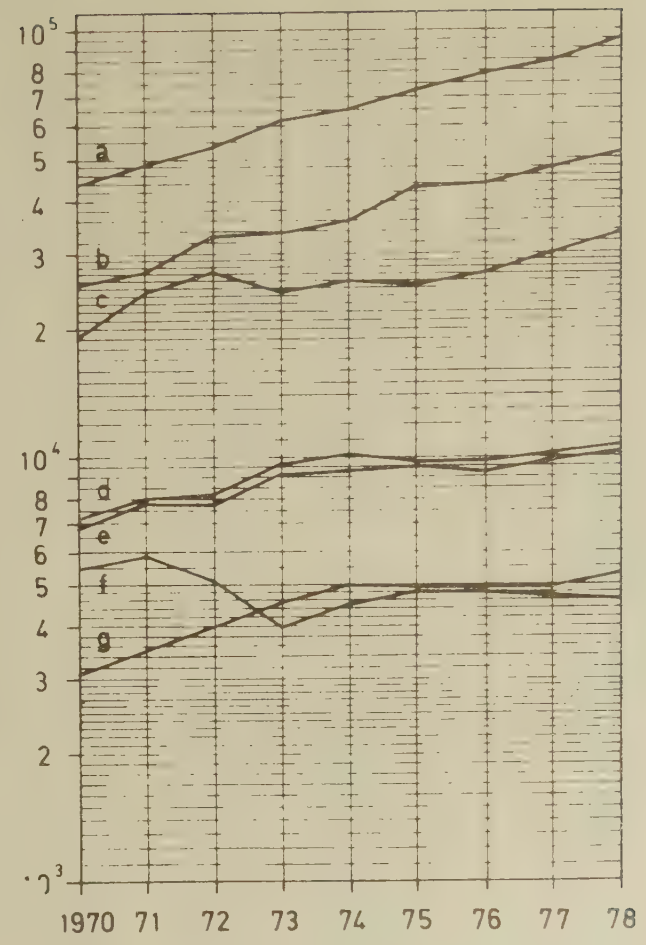



Fig.2: Relationship between the number of some fishing gear, fishermen, fishing boat and total catch in the coastal fisheries (in tons) in the period after 1970

a - gill net, b - trammel net,
c - pot, d - fishing boat,
e - fishermen, f - total catch,
g - lamp for tridents

Annex H

# STATISTICAL ANALYSIS OF FISHING EFFORT PER FISHING GROUNDS

by

S. Despot

At its Thirteenth Session the General Fisheries Council for the Mediterranean (GFCM) recommended that all its member countries adopt unique statistical indicators in order to facilitate comparative analysis of the results of the fishery statistics.

Acting on this recommendation the Statistical Institute of the Republic of Croatia has introduced the fishing effort in the fishery statistics. This indicator enables the examination of the wealth of the sea, determination of the biological and economical levels of fishery resources and, as a result, determination of the basis for more rational exploitation of sea resources.

With this purpose, 21 fishing squares (1-21) in the Adriatic Sea have been defined the limits of which are defined by geographical coordinates. The recording of the results by fishing squares started in 1976, so that we now have the results for 1976, 1977, 1978, and 1979 (for 1979, the results are preliminary). The results are collected from the reporting units, e.g., the fishing vessels owned by the organization of associated labour and agricultural cooperatives, on the basis of the daily questionnaires.

In the following the results per fishing squares have been presented for the past four years, separately for the catch of the purse seiners and trawlers. The following data have been collected:

frequency of fishing vessels per fishing grounds;

number of fishing days;

catch per purse seine operation;

catch per drift;

number of fishing hours.

On the basis of these data, a statistical analysis was made to test whether there exist differences in the catch among fishing squares. As we dispose of the data for only the last four years, the basis for the calculation is the four-year average.

One can notice significant differences among the total catch within the squares. (It is obvious that total catch depends on the number of different factors like: geographical position, fishing resources, technical and technological equipment of the vessels, etc.) The range of total catch from minimum to maximum is very wide and significantly deviates from arithmetic mean, and the standard deviation is very big $\delta$ = 2 247,49 and it is bigger than the arithmetic mean. The coefficient of variation is V = 112,5%.

However, the important indicator is the fishing effort. The data on fishing effort per fishing squares for vessels with purse seines show that there exist differences but they are much smaller than in the case of total catch. The fishing effort is therefore rather equally distributed in each fishing square even if there are considerable differences in the total catch. Standard deviation is $\delta$ = 773,00 and the coefficient of variation V = 28,1%.

The results of the catch analysis among fishing squares referring to trawl fishing show considerable variation between fishing squares. Most of the fishing squares (about one half) show rather equal catch. Standard deviation is $\delta$ = 27,20 and the coefficient of variation V = 58,8%.

Data on vessels with purse seines
per fishing squares in 1976, 1977, 1978 and 1979

| No. of vessels | | | | | Total catch | | | | | Catch per operation | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | tons | | | | | kg | | | | |
| 1976 | 1977 | 1978 | 1979 | average 1976–1979 | 1976 | 1977 | 1978 | 1979 | average 1976–1979 | 1976 | 1977 | 1978 | 1979 | average 1976–1979 |
| 455 | 410 | 386 | 405 | 414 | 6 186 | 4 136 | 9 346 | 8 702 | 7 093 | 1 782 | 1 669 | 2 849 | 1 866 | 2 042 |
| 74 | 80 | 76 | 53 | 71 | 1 172 | 1 903 | 1 370 | 956 | 1 350 | 2 967 | 4 101 | 3 464 | 2 542 | 3 268 |
| 256 | 238 | 203 | 165 | 216 | 2 697 | 2 503 | 2 632 | 2 423 | 2 564 | 2 162 | 2 617 | 2 637 | 2 337 | 2 438 |
| 393 | 317 | 256 | 183 | 287 | 6 717 | 8 621 | 5 554 | 3 524 | 6 104 | 1 890 | 3 630 | 3 642 | 3 382 | 3 136 |
| 67 | 79 | 65 | 101 | 78 | 542 | 719 | 1 246 | 1 678 | 1 046 | 1 593 | 2 233 | 3 654 | 2 878 | 2 590 |
| 24 | 11 | 14 | 8 | 14 | 185 | 145 | 267 | 30 | 154 | 2 254 | 3 372 | 3 985 | 1 358 | 2 742 |
| 186 | 172 | 184 | 107 | 162 | 2 902 | 3 295 | 3 172 | 1 957 | 2 832 | 2 057 | 1 901 | 2 835 | 2 596 | 2 347 |
| 105 | 126 | 92 | 69 | 98 | 1 904 | 2 344 | 1 537 | 1 207 | 1 748 | 2 194 | 2 691 | 2 917 | 2 762 | 2 641 |
| 7 | 8 | – | 4 | 5 | 53 | 79 | – | 17 | 37 | 1 295 | 1 696 | – | 813 | 951 |
| 14 | 6 | 12 | 29 | 15 | 220 | 222 | 105 | 640 | 297 | 2 179 | 6 721 | 2 625 | 3 046 | 3 642 |
| 21 | 12 | 24 | 32 | 22 | 452 | 148 | 346 | 338 | 321 | 3 501 | 2 349 | 3 720 | 2 728 | 3 075 |
| 22 | 28 | 15 | 22 | 22 | 627 | 768 | 197 | 154 | 436 | 5 484 | 3 183 | 5 794 | 1 931 | 4 098 |
| 1 | – | – | – | 0 | 1 | – | – | – | – | 108 | – | – | – | – |
| – | – | | – | – | – | – | – | – | – | – | – | – | – | – |

Data on vessels - trawls
per fishing squares in 1976, 1977, 1978 and 1979

| No. of vessels | | | | Total catch | | | | | Catch | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | tons | | | | average 1976-1979 | per hour (kg) | | | | average 1976-1979 |
| 1976 | 1977 | 1978 | 1979 | 1976 | 1977 | 1978 | 1979 | | 1976 | 1977 | 1978 | 1979 | |
| 11 | 22 | 21 | 26 | 56 | 51 | 29 | 32 | 42 | 18 | 18 | 46 | 48 | 32 |
| 46 | 26 | 55 | 77 | 51 | 64 | 57 | 83 | 64 | 11 | 14 | 10 | 15 | 12 |
| - | - | 1 | 1 | - | - | 1 | 2 | 1 | - | - | 45 | 31 | 19 |
| 18 | 6 | 20 | 29 | 140 | 167 | 23 | 36 | 92 | 49 | 67 | 15 | 49 | 45 |
| 176 | 173 | 184 | 110 | 56 | 61 | 280 | 138 | 134 | 10 | 10 | 10 | 14 | 11 |
| 13 | - | 1 | 1 | 50 | - | - | 2 | 13 | 7 | - | 12 | 6 | 6 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 56 | 57 | 23 | 11 | 176 | 172 | 165 | - | 128 | 40 | 38 | 32 | 39 | 37 |
| 20 | 2 | 17 | - | 88 | 90 | 57 | 64 | 75 | 21 | 25 | 18 | - | 16 |
| 1 | - | - | - | 95 | - | - | - | 24 | 39 | - | - | - | 10 |
| 1 | - | - | - | 98 | - | - | - | 24 | 28 | - | - | - | 7 |
| 11 | 3 | 6 | - | 134 | 149 | 9 | - | 73 | 38 | 43 | 18 | - | 25 |
| 13 | 7 | 9 | - | 150 | 163 | 17 | - | 83 | 38 | 49 | 59 | - | 37 |
| 15 | 8 | 9 | 5 | 78 | 175 | 28 | 4 | 71 | 25 | 48 | 44 | 16 | 32 |
| 13 | 15 | 10 | - | 166 | 87 | 26 | - | 70 | 23 | 25 | 28 | - | 19 |

The data on the catch per hour with trawlers show considerable variation as well, more important than the catch per hour with purse seiners. Standard deviation is $\delta$ = 11,80, and coefficient of variation V = 54,7%.

Considering these results, one can say that variability in the total catch per hour is rather equal within fishing squares. This does not mean that the total catch per hour vary simultaneously in all the fishing squares but that as a whole, the degree of variation almost identical. Most of the data (75%) had been collected in the social sector and the rest of the results, concerning the catch of the vessels owned by individual fishermen (private sector) has been estimated.

We must stress that there still exists a number of problems concerning either quantity or quality of collected data.

Taking into account the fact that we are expecting some corrections of the fisheries legislation through which the conditions for fishing as a supplementary occupation (or part-time job) will be strictly defined, we think that more up-to-date data on individual fishermen's catch will be obtained. The allowed catch in the hobby-fishing will be precisely determined and it will be forbidden to increase without control the basic fishing means and the number of their users. As a means of protection from irrational overexploitation of the fishing resources the data of the catch and the fishing effort should be recorded. This should be an obligation for all fishing organizations of associated labour (until now the reporting of these data has been on a voluntary basis).

Apart from this, the Statistical Institute collects and has at its disposal the following data:

Total catch (monthly and annualy), number of fishermen and others engaged in fishery, basic means of fishery, fishing fleet and equipment.

As the fishery, as a branch of economy spreads into different branches of activity and includes a great number of indicators, different statistical research is used in collecting different data in order to get better insight in the state and processes of this branch of economy. A short description of contents of statistical indicators in different branches of activity is given for information.

Statistics of employment: They concern the data on persons employed in fishing organizations of associated labour and agricultural cooperatives relating to the annual average of the employed people, according to level of professional education and level of professional qualifications, utilization of hours of work,etc. The data on persons employed at private employers are also collected by regular reporting service.

Statistics of manufacturing, mining and quarrying: They concern the data on industrial production by month and year for some products of food manufacturing industries (canned fish, salted fish, frozen, dried, smoked fish, fish-oil and fish flour).

Statistics of prices: They concern the data on producers' prices of some fishery products as well as the trading on the market.

Statistics of domestic trade: They concern the data on sales in retail trade for some articles - salt and fresh fish, dried, smoked and salted fish.

Statistics of authorized purchase of fishery products: They concern the data on purchase of fishery products from individual producers as well as the sale from organization of associated labour.

Statistics of external trade: They concern the data on import and export of some sort of fish by different countries.

Statistics of investment: They concern the data on investment in fixed assets by sources of finance and assets of collective consumption.

Statistics of economic balances and national income: They show the data covering computation of gross product, depreciation and national income, its distribution and redistribution for the fishery in private and social sectors.

The data on consumption are collected by regular or temporary surveys. There exist some other sources of data: censuses, sample surveys, estimates, etc., from which a number of data on fisheries can be obtained.

## Annex 1

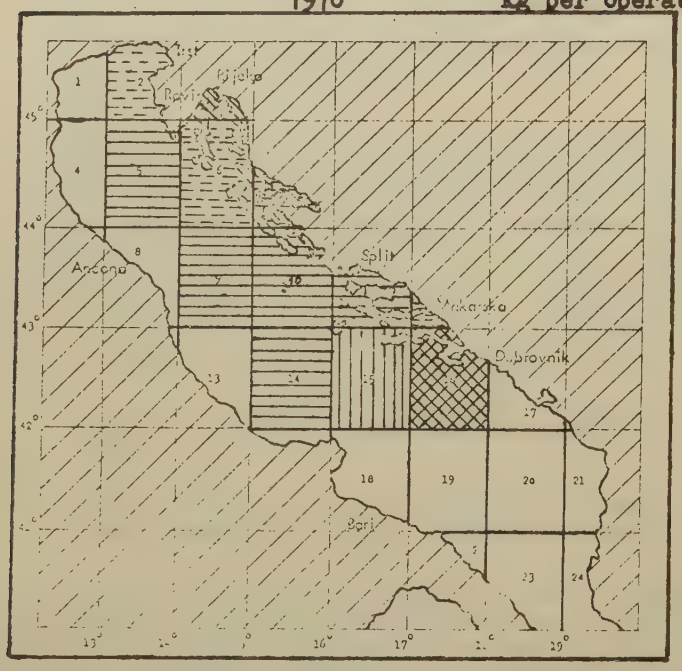
CATCH PER OPERATION

FISHING EFFORT PER FISHING SQUARES

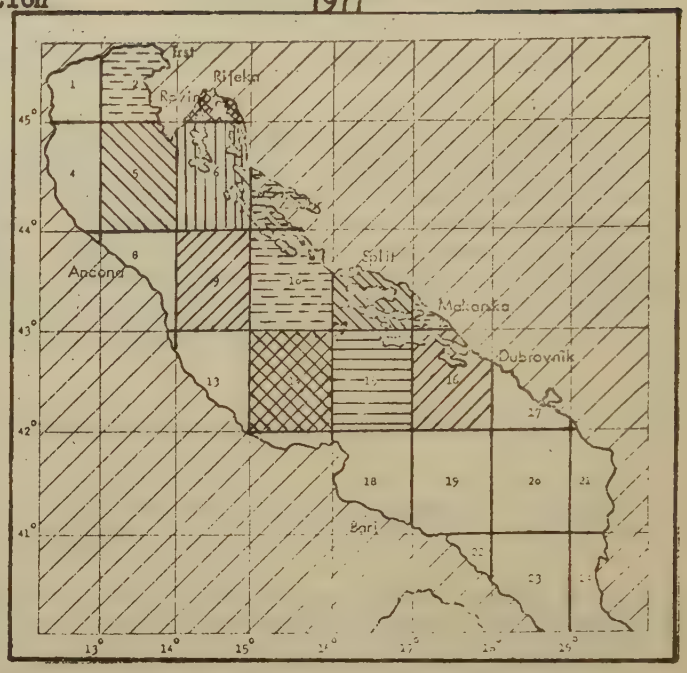
DATA ON PURSE SEINERS

up to 2 000 kg
2 001-2 500 kg
2 501-3 000 kg
3 001-3 500 kg
3 501-4 000 kg
above 4 000 kg

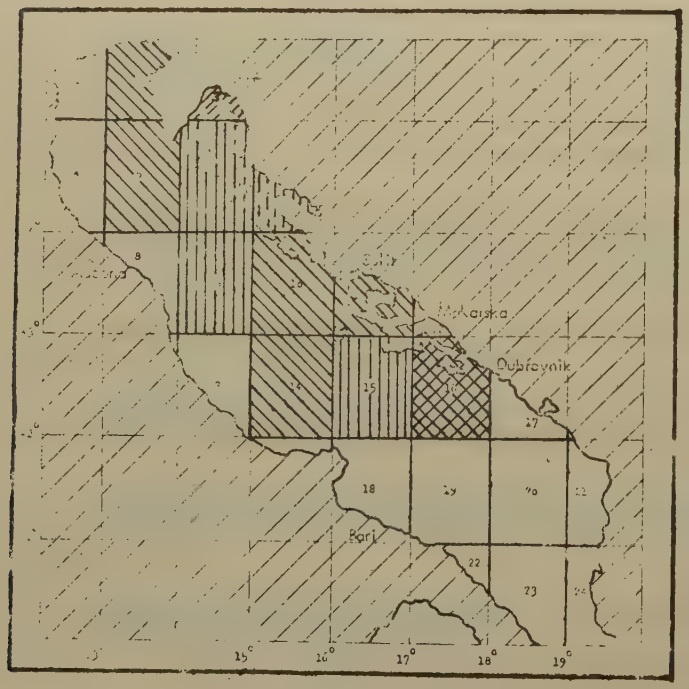
1976 kg per operation



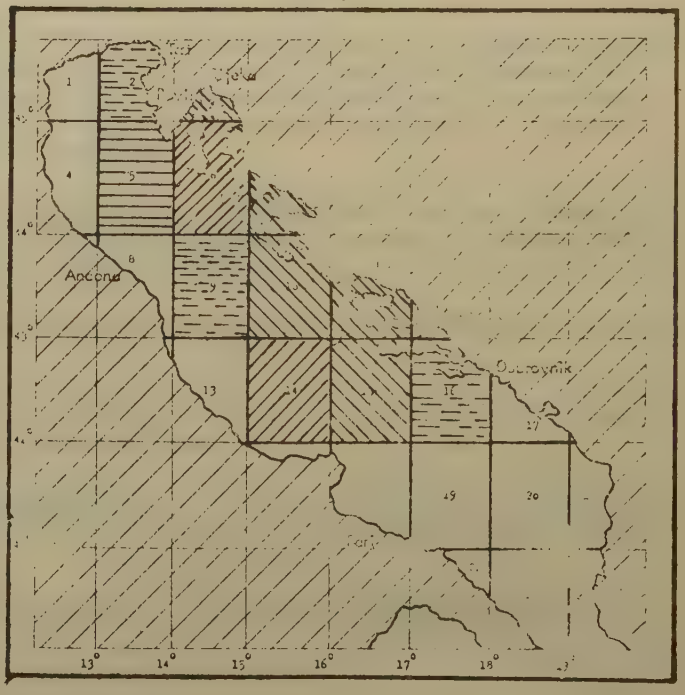

1977




1978




1979



## Annex 2

CATCH PER HOUR

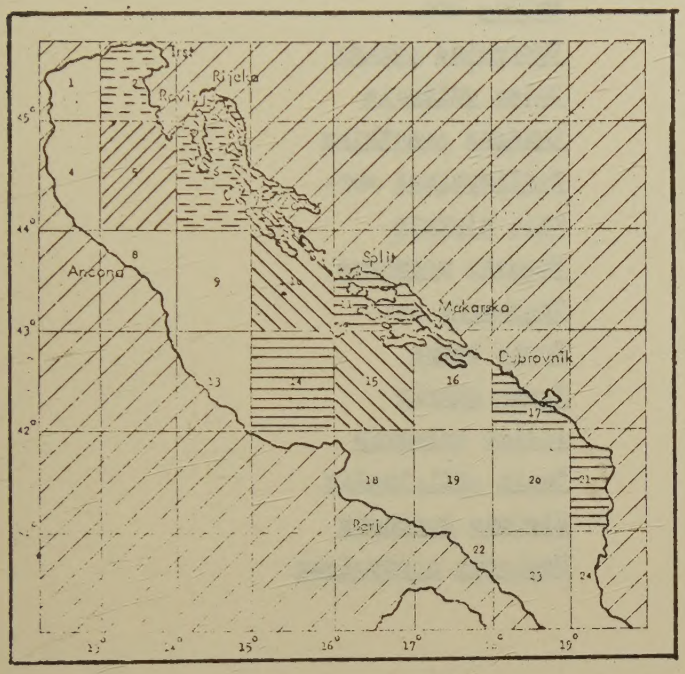
FISHING EFFORT PER FISHING SQUARES

DATA ON TRAWLERS

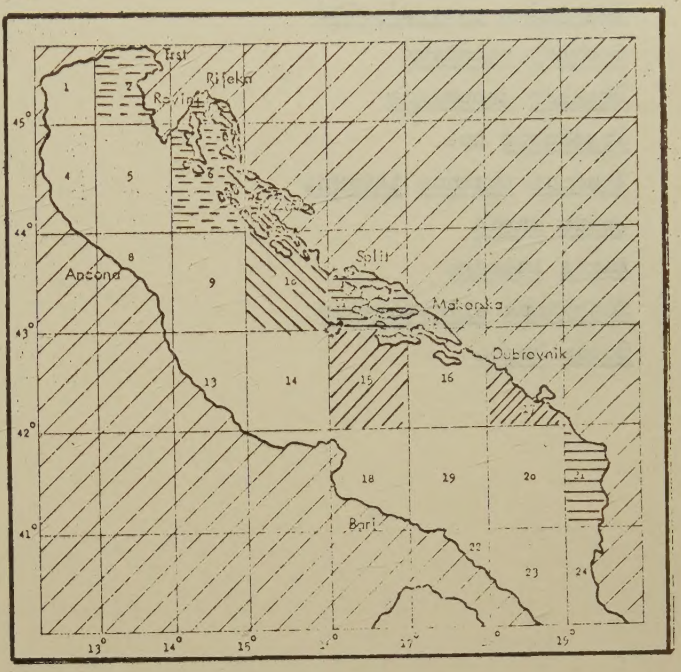
up to 20 kg
21-31 kg
31-40 kg
41-50 kg
above 50 kg

1976

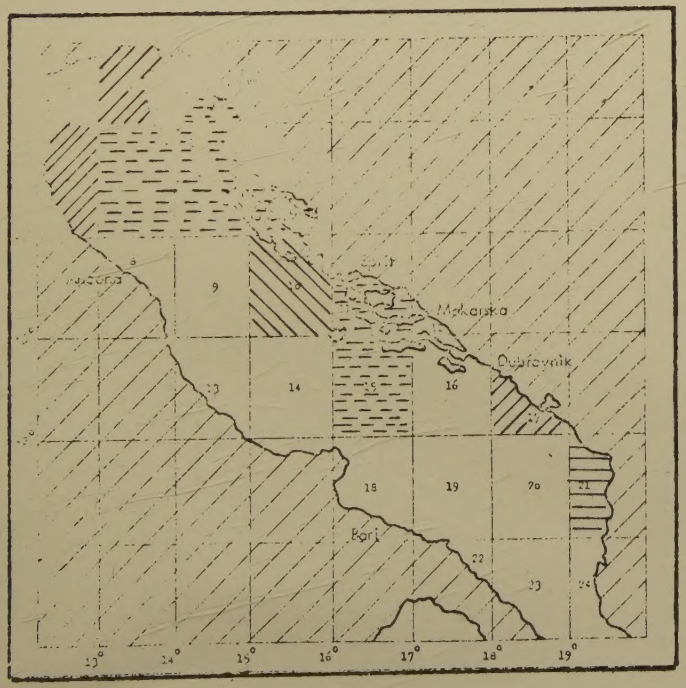
kg per hour



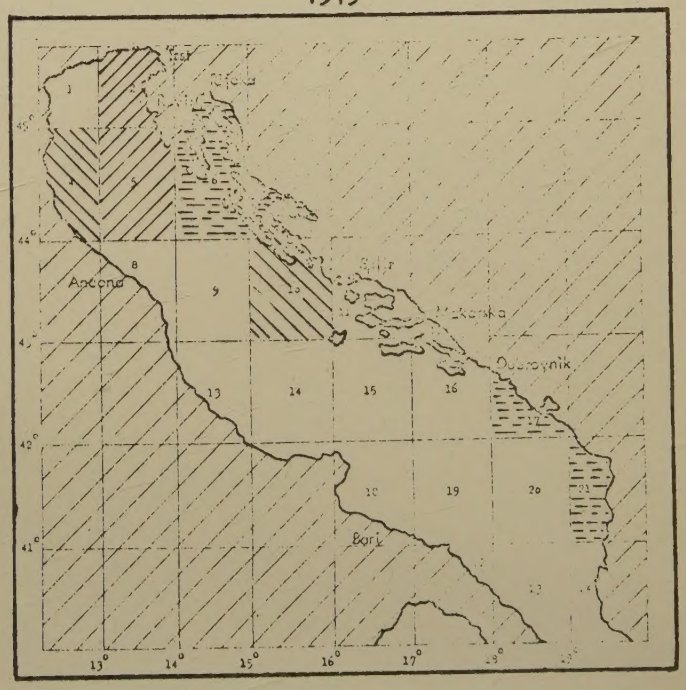

1977




1978




1979



## Annex 3

SPECIES FOR WHICH CATCHES ARE REPORTED

| Purse Seine | Trawl |
|---|---|
| Sardina pilchardus | Merluccius merluccius |
| Sprattus sprattus | Gadus sp. |
| Engraulis encrasicolus | Mullus spp. |
| Scomber scombrus | Scorpaena porcus |
| Scomber japonicus | Solea vulgaris |
| Trachurus sp. | Squalus acanthias |
| Thunnus thynnus thynnus | Scyliorhinus spp. |
| Sarda sarda | Raja clavata |
| Auxis thazard | Scomber scombrus |
| Euthynnus alletteratus | Trachurus sp. |
| Boops boops | Boops boops |
| | Maena smaris |
| | Loligo vulgaris |
| | Sepia officinalis |
| | Eledone moschata |
| | Nephrops norvegicus |

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